VESTA SMART HOME

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SERV 748 MA FINAL PROJECT

A home that understands you—adapting, optimizing, and seamlessly integrating into daily life. This process book is a journey through design, technology, and human behavior—where sustainability meets comfort, and innovation feels effortless."

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01. PROJECT OVERVIEW

PROJECT OVERVIEW

Smart home technology has immense potential to enhance energy efficiency and user convenience. However, renters face significant barriers to adoption, such as installation restrictions, fragmented ecosystems, and lack of personalization. This project explores how service design can bridge the gap between technological innovation and user needs, ensuring that smart home solutions are not just available but truly accessible to all.

My approach is rooted in human-centered design and service thinking—understanding the pain points users face and crafting a system that seamlessly integrates into their daily lives. This process book outlines my journey, from problem discovery to research insights, concept iterations, and final recommendations.

My research journey started with a broad exploration of technology and sustainability but gradually refined into a human-centered service design challenge. By systematically analyzing user behavior, industry limitations, and service opportunities, I shaped Vesta into a smart home system designed for accessibility, adaptability, and seamless user experience.
This structured research plan reflects my approach: deep exploration, user-driven insights, iterative prototyping, and service thinking to create an impactful solution.

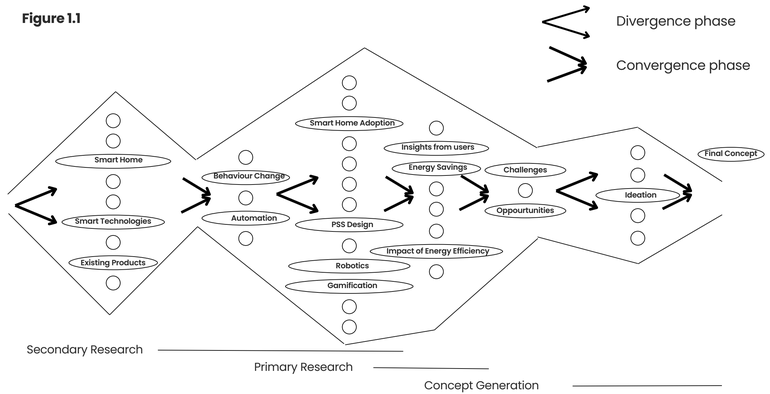
Project timeline

At the start of my Service Design final project, I had to quickly shift my focus from my previous MA in Design for Sustainability research topic —"Emerging Circular Innovation in Existing Business Models and Adoption of Flexible Consumption Models to Combat E-waste." Since I had already explored that topic extensively, I decided to pivot towards a new area of interest: "Smart Technologies in Conjunction with Energy Saving & Comfort in a Home Environment."

To develop a well-rounded understanding of this topic, I pursued a mixed-method research approach, integrating both quantitative and qualitative methodologies. My research explored behavioral psychology, sustainability, socio-dynamic influences, and cultural impact within the context of smart home technologies.

I adopted a divergence-convergence research method (Fig 1.1), where I initially conducted broad exploratory research before narrowing my focus.

Figure 1.1



Project timeline

To ensure a well-structured and multi-faceted research approach for my 10-week Service Design project, I developed a week-by-week research plan in the form of a table. This plan outlined a mixed-method research strategy, integrating diverse methodologies to provide a comprehensive perspective on my topic.
By incorporating a structured breakdown, I was able to systematically explore, analyze, and synthesize findings across different dimensions of my research. This approach allowed me to stay focused while ensuring that my research remained dynamic and adaptable.

Methods	Week 2	Week 3	Week 4	Week 5	Actions Completed
Interviews	Pilot Interviews	Low-Income Household Interviews			Pilot Study with targeted questions to refine interview strategy (6 users)
Behavioral Journals	Distribution	Collection	Analysis		Distribute and Monitor behaviour study (4 users)
Competitive Analysis	Secondary Research on products	Measuring sustainability impact	Revaluation	Mapping	Analyse competitors for gaps and trends
Case Studies		Review from all industries	Interrogating findings		Review successful/ failed systems for insights
Trend Analysis		Look at cutting edge technology	Narrow down oppourtunity areas	establish metrics for trends	Study reports from McKinsey, WEF, and IEA to identify future trends in AI, IoT, and smart home systems.
Interviews with Experts				interview behavioural and industry specific experts	Gain insights into the industry's long-term vision and barriers to adoption.
ERAF/ Ecosystem Mapping		Understand different parts of the system	Make an accurate map with my design intervention		Synthesise findings into a cohesive system map
Affinity Mapping				Synthesise my findings from primary research	Organize and cluster primary research findings (e.g., interview and journal data) to identify key themes.
Triangulation of Insights			Start gathering and triangulating data	Triangulated insights generation	Cross-validate findings from primary research, secondary sources, and competitive analysis.

Methods	Week 6	Week 7	Week 8	Week 9	Week 10	Actions Completed
Concept Development	Refine smart home intervention concept.	Develop AI-based automation models.	Integrate gamification & predictive automation.	Refine concept based on testing feedback.		Concept refinement based on research, interviews, and behavior journals.
Value Proposition Mapping	Map specific incentives & engagement models.	Map value exchange between users & providers.				Mapped user needs to core value propositions for seamless smart home experience.
Service Metrics		Define key success metrics.		Validate service metrics through testing.		Established key success metrics for usability, efficiency, and adoption.
User Journey	Refine user journey with pain points.	Finalize service blueprint.		Finalize journey maps with testing insights.		Developed comprehensive user journey maps to enhance service experience.
Business Model Canvas			Outline business model structures.			Defined business model structures for renters & homeowners.
Lo-fi Prototyping	Develop wireframes & sketches.	Develop interactive wireframes.				Created interactive wireframes and lo-fi prototypes for validation.
User Testing			Conduct early usability testing.	Summarize user feedback insights.		Tested early prototypes with users and refined key automation features.
Hi-fi Prototype				Develop high-fidelity prototype.	Deliver final prototype with documentation.	Built and tested a high-fidelity prototype integrating AI automation.
Process Book					Submit final project deliverables.	Compiled all findings, design frameworks, and strategies into the final process book.

To ensure a comprehensive and well-balanced research process, I employed a mixed-method approach, integrating qualitative, quantitative, and analytical methodologies. Each method was chosen to address specific aspects of the project, ensuring depth, real-world applicability, and strategic insights.

Figure 1.2

Methods	Reason for Selection	Suitability
Interviews	To gather qualitative insights into user behaviors, preferences, and barriers.t-saving, energy efficiency	Provides depth and real-world context directly from target users (e.g., low-income households, renters).
Behavioral Journals	To track unconscious habits and patterns in resource usage over time.	Captures real-life behaviors in situ, complementing interview data.
Competitive Analysis	To evaluate existing smart home solutions and their strengths, weaknesses, and gaps.	Identifies market gaps and informs potential differentiation strategies.
Case Studies	To analyze successful and unsuccessful implementations of similar systems or technologies.	Provides benchmarks for best practices and insights into challenges faced by others.
ERAF/ Ecosystem Mapping	To structure findings into actionable insights and iterative feedback loops.	Integrates insights from all methods to guide conceptualization and design.

This structured approach allowed me to build a strong foundation, ensuring that the final solutions were user-centered, strategically positioned, and aligned with real-world needs.

RESEARCH METHODOLOGIES

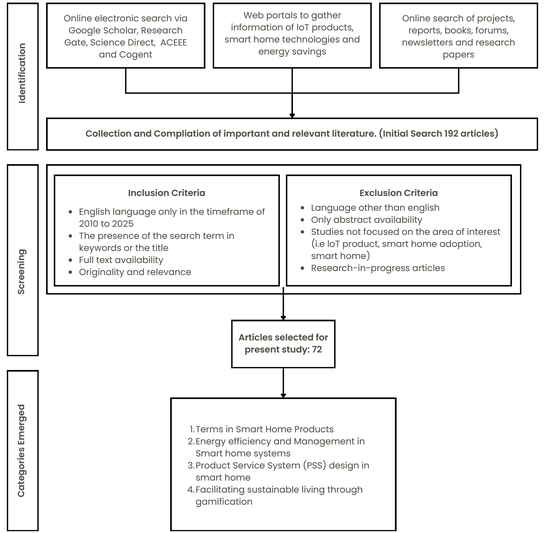
I conducted a systematic literature review focused on smart home technologies, energy efficiency, and sustainable living. My research process followed a structured identification, screening, and categorization method (Figure 1.3) to gather relevant insights and shape my design perspective.

I began with an extensive online search across academic databases and industry sources, compiling 192 articles related to IoT products, smart home adoption, and energy management. Applying inclusion and exclusion criteria, I refined this selection to 72 key studies, ensuring credibility, relevance, and applicability to my project.

From this review, four key categories emerged, forming the foundation of my research:

1. Terms in Smart Home Products
2. Energy Efficiency & Management in Smart Home Systems
3. Product-Service System (PSS) Design in Smart Homes
4. Facilitating Sustainable Living through Gamification

Figure 1.3



I further categorized these 72 selected articles into different aspects of my mixed-methods research (Figure 1.4), ensuring a balanced approach across theoretical, qualitative, and quantitative perspectives. This segregation helped me assess whether my research was comprehensive and covered diverse methodologies effectively.

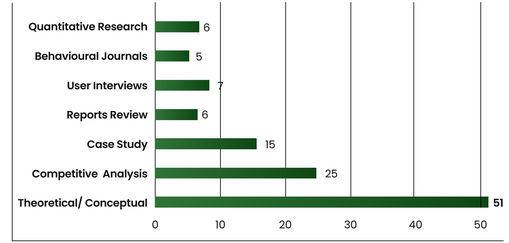


Figure 1.4

02. SECONDARY RESEARCH

BACKGROUND: SMART HOME TECHNOLOGY

Narrowing Down the Scope: Addressing Resource Inefficiencies in the Built Environment

Buildings—whether residential, commercial, or mixed-use—are the backbone of modern life. Yet, they are also the largest contributors to energy consumption, water waste, and solid waste generation. As I explore service design interventions for sustainability, I see a critical opportunity to address these inefficiencies at the intersection of system design, user behavior, and technological innovation.

URBAN ENVIRONMENTS

Smart Cities like Singapore are designed to reduce inefficiencies but face challenges integrating citizen behavior into sustainability frameworks.

Singapore Smart Nation Report, 2023

RESIDENTIAL SPACES

20–30% of energy is wasted through standby power and inefficient HVAC systems.

40% of water waste stems from behaviors like running half-full dishwashers and long showers.

McKinsey Smart Home Report, 2023

COMMERCIAL AND OFFICE SPACES

Offices waste 30% of energy daily, particularly through HVAC systems left running after hours.

Behavioral nudges and automated systems could save $50 billion annually in global operational costs.

Energy Star, 2024

My Focus

As I narrowed my scope, I recognized that residential spaces and smart homes offer the highest potential for immediate, scalable impact in reducing energy, water, and material waste. While commercial buildings and urban infrastructure are crucial, they often require large-scale regulatory changes and long-term investments. On the other hand, residential spaces present a unique opportunity to drive change at the individual level, leveraging service design to make sustainability more accessible and actionable for everyday users.

Market Gap

Despite advancements in technology and growing environmental awareness, 60% of global energy consumption comes from residential and commercial buildings, yet only 30% of households globally use energy-efficient solutions ***(International Energy Agency, 2023)***. This highlights a massive untapped potential for leveraging AI and automation to drive sustainability.

The intention-action gap is stark: While 76% of consumers claim they are willing to adopt sustainable behaviors, only 25% consistently practice eco-friendly habits ***(Deloitte Sustainable Consumer Report, 2023)***. Bridging this gap through behavior-driven, automated systems could create a lasting impact on individual households and global sustainability.

Why it matters

The problem is not just about lack of awareness but about unconscious behaviors—everyday decisions like leaving devices on standby, overusing water, or heating empty rooms collectively contribute to 20–30% of resource waste in residential settings ***(Energy Star, 2024)***. This presents an opportunity to automate behavioral change to address inefficiencies at scale.

WHAT IS A SMART HOME?

According to multiple sources I have citied here, smart homes can be defined in various ways:

Smart home technology is, in effect, the controller of all things automated in the home. It's the concept that allows your devices and your systems to communicate with one another, and with you, whether you're home or not.

Aterra Designs, 2022

A smart home is a residential space containing a network of sensor-based technologies that are used to monitor, control, and automate processes within the home environment

Marikyan et al., 2019, p. 139

UNITED NATIONS
Smart living aligns with sustainable development goals

INTERNATIONAL ENERGY AGENCY
Smart living prioritizes energy efficiency through automation.

APPLE
Emphasizes privacy and seamless integration.

AMAZON
Promotes ease of use and cost savings.

TESLA
Prioritizes energy autonomy via decentralized systems.

MCKINSEY
Focuses on the intersection of comfort, technology, and sustainability.

> *But, the concept of a 'smart home' is a fluid one, with the expectations we have of home technology and the Internet of Things constantly growing.*

Definition of Smart Homes for My Project

For me, smart homes represent more than just technology integration within a living space—they are dynamic ecosystems that merge automation, data, and user engagement to drive sustainable living. A smart home is designed to:

- **Optimize Resource Use:** By leveraging real-time monitoring and automated controls, smart homes minimize energy and water waste, directly addressing inefficiencies inherent in traditional residential settings.
- **Enhance User Behavior:** Through behavioral nudges, intuitive interfaces, and personalized feedback, they empower residents to make more sustainable choices effortlessly.
- **Bridge Technology and Daily Life:** Smart homes are not merely about high-tech gadgets; they create an environment where technology supports and enriches everyday living, seamlessly integrating into the rhythms of daily life to foster a culture of sustainability.

In essence, my vision of smart homes is one where technology is harnessed as a tool for sustainable transformation—making residential spaces active contributors to energy efficiency and environmental stewardship.

Difference between smart home & home automation

As I delved into the project, I realized that the terms "smart home system" and "home automation system" are often used interchangeably, yet they embody two distinct design philosophies and operational frameworks.

Figure 2.1

Key Differences	Smart Home System	Home Automation System
Defination	Refers to a network of connected devices that can be controlled remotely via an app or voice command, often utilizing cloud-based servers and internet connectivity	Focuses on automating specific tasks within a home, usually through pre-programmed rules and triggers, with or without internet access, allowing for more complex control sequences and integration with existing home systems.
Connectivity	Smart homes heavily rely on internet connectivity to access data and control devices through cloud-based platforms	Home automation systems may operate with or without an internet connection depending on the setup.
Flexibility	Smart homes usually offer more flexibility in terms of device selection and customization through various app-based controls.	Home automation systems might be more limited to specific brands or pre-defined functions.
Intelligence	Smart homes often incorporate AI and machine learning capabilities to adapt to user behavior and provide more personalized experiences	Traditional home automation systems primarily rely on pre-set schedules and triggers.
Examples	Smart lights, Smart thermostats, Smart locks, Smart speakers, and Security cameras.	Automated lighting based on time of day, Pre-set "scenes" to control multiple devices simultaneously, Integrated security systems with motion sensors and alarms, Automated window treatments, and Remote control of appliances.

In my exploration, I started by questioning: What does a truly "smart" home look like? I looked beyond the buzzwords and analyzed the core functionality of each system. I discovered that while home automation can reliably manage daily tasks through fixed routines, smart home systems elevate the user experience by learning and adapting—paving the way for more sustainable and intuitive living environments.

By understanding these nuances, I was able to pinpoint which aspects of each system could be harnessed for a more sustainable and user-centric design. My aim became clear: to create an environment that not only automates tasks reliably but also anticipates and responds to human behavior, ultimately bridging technology and everyday life in a way that encourages sustainable practices.

This differentiation was pivotal in shaping my approach, helping me strike a balance between the stability of traditional automation and the dynamic, personalized potential of smart home technology.

MARKET ANALYSIS

Market Size

TAM (TOTAL ADDRESSABLE MARKET)

This represents the global revenue opportunity for smart home technologies. According to Fortune Business Insights, the global smart home market is projected to grow from approximately $147.52 billion in 2025 to $633.20 billion by 2032.

Fortune Business Insights. (2025)

SAM (SERVICEABLE AVAILABLE MARKET)

This refers to the portion of the TAM specific to the U.S. market. Estimates vary, but according to Fortune Business Insights, the U.S. smart home market is expected to reach around $105.25 billion by 2032.

Fortune Business Insights. (2025)

SOM (SERVICEABLE OBTAINABLE MARKET)

Focusing on smart home technologies for energy saving and sustainable living, the U.S. energy management segment is a key area. According to Statista, revenue in the U.S. energy management market is projected to reach approximately $3.4 billion in 2025.

Statista. (2025)

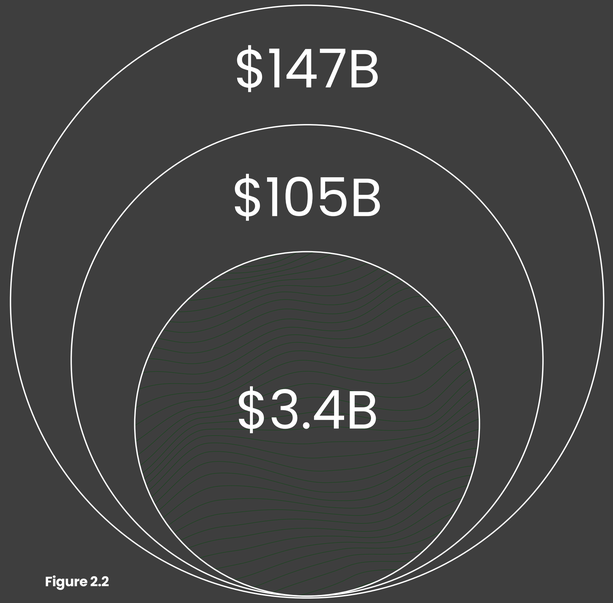
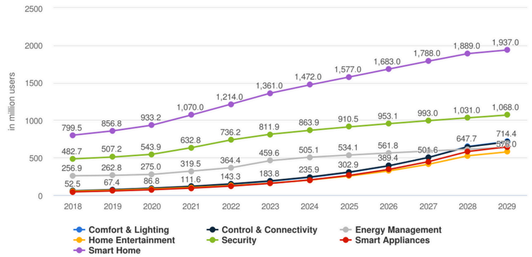


Figure 2.2

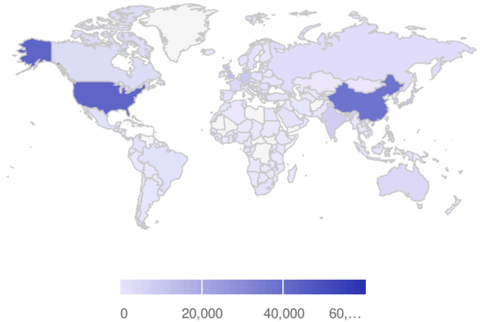
SMART HOME: WORLDWIDE USERS



This line graph displays the global number of smart home users categorized by different smart home segments from 2018 to 2029. The vertical axis represents the number of users (in millions), while the horizontal axis represents the years.

Statista 2025

SMART HOME: WORLDWIDE REVENUE CAMPARISON BY LOCATION



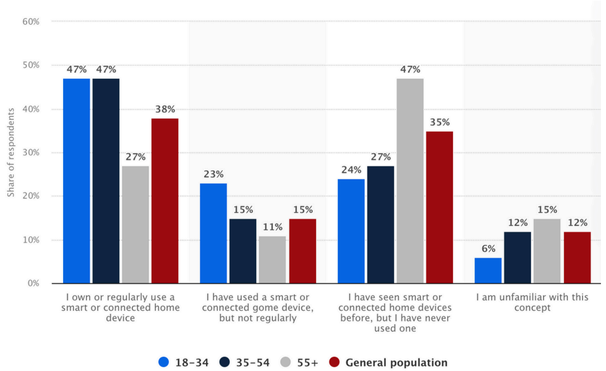
This heatmap illustrates the global revenue distribution of the smart home market, where darker shades represent higher revenue concentrations.

Statista

Demographic

SMART HOME USERS: AGE GROUPS

Statista



This bar chart illustrates the distribution of smart home users across different age groups in the United States, based on a survey conducted from October 13 to 20, 2022, with 1,904 respondents aged 18 and older.

History of smart homes

1990s
- Used for home automation.
- The network was built using broadband internet

2000s
- Saw advent of smartphones and applications.
- Move towards home networks, whose main function was to control and monitor devices.

2010s
- Incorporated Internet of Things (IoT) and Artificial Intelligence (AI) technologies.
- Main application shifted to context awareness, which arises the need for user-centric research (Yang et al., 2018).

2020s
- In the next five years, smart home systems will evolve into fully integrated ecosystems driven by the Artificial Intelligence of Things (AIoT).
- catering to user behaviour and needs.

01.

SMART THERMOSTATS

According to the U.S. Department of Energy, smart thermostats can save up to 10% on heating and cooling costs annually.

SOURCE

02.

ENERGY-EFFICIENT LIGHTING

Switching to energy-efficient lighting, such as LED bulbs, can reduce energy consumption and lower electricity bills.

SOURCE

03.

GREEN BUILDING INVESTMENTS

Investing in green building practices can lead to higher property values and rental premiums. Properties with green certifications see rental premiums of up to 15% and resale values that can exceed non-certified counterparts by 10-20%.

SOURCE

04

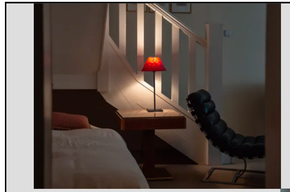
COMPREHENSIVE RENEWABLE ENERGY SOLUTIONS

Adopting a combination of renewable energy solutions, such as solar panels, battery storage, and heat pumps, can lead to substantial savings. A retired couple reduced their energy bills by over £200 a month, achieving annual savings of nearly £3,000.

SOURCE

The Power of Small Sustainable Actions

When I first started researching smart home technologies, I recognized their potential to create meaningful and scalable sustainability impact. Unlike large-scale industrial sustainability efforts, smart homes offer a unique opportunity for individuals to engage in small, unconscious sustainable actions—daily habits that, when automated and optimized, can lead to significant environmental and financial savings over time.



01.

LEAVING LIGHTS ON

Forgetting to turn off lights when exiting a room wastes electricity and increases utility bills. Switching to energy-efficient LED bulbs and being diligent about turning off lights can lead to savings.

source

02.

USING INCANDESCENT BULBS

Traditional incandescent bulbs consume more energy compared to LED alternatives, leading to higher electricity costs. Replacing them with LEDs reduces energy consumption and saves money over time.

source

03.

LEAVING ELECTRONICS PLUGGED IN

Devices left plugged in, even when not in use, can draw "phantom" energy, contributing to unnecessary energy usage and expenses. Unplugging electronics or using power strips to turn off multiple devices at once can mitigate this issue.

source

04.

OVERUSING DRY CLEANING SERVICES

Regularly sending clothes to the dry cleaner, especially when not necessary, incurs additional costs and involves chemicals that may harm the environment. Opting for at-home cleaning methods when appropriate can reduce expenses and environmental impact.

source

05.

FREQUENT TAKEOUT AND DINING OUT

Regularly eating out or ordering takeout is often more expensive than cooking at home and generates more waste, such as single-use plastics. Preparing meals at home can be more economical and environmentally friendly.

source

06.

PAYING FOR UNUSED SUBSCRIPTIONS

Maintaining subscriptions for services or magazines that are seldom used leads to unnecessary monthly expenses. Regularly reviewing and canceling unused subscriptions can free up funds for more essential needs.

source

07.

IMPULSE BUYING

Making spontaneous purchases, especially for items that are not needed, can strain finances and contribute to clutter and waste. Implementing a waiting period before making non-essential purchases can help curb this habit.

source

08.

OVERLOOKING APPLIANCE SETTINGS

Not utilizing energy-saving modes on appliances like washing machines or dishwashers can lead to higher energy consumption. Familiarizing oneself with and using eco-friendly settings can reduce utility bills.

source

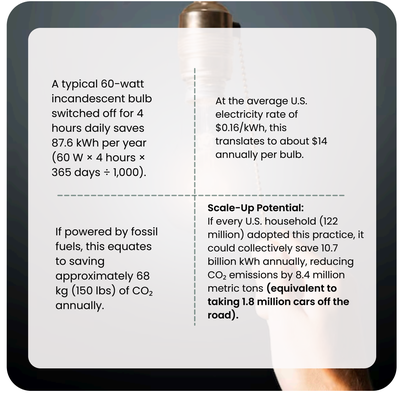
SUSTAINABILITY ISN'T JUST ABOUT BIG, CONSCIOUS ACTIONS—IT'S ABOUT MAKING SMALL ACTIONS INVISIBLE, EFFORTLESS, AND HABITUAL.

AUTOMATION ISN'T JUST ABOUT CONVENIENCE—IT'S ABOUT SCALING SUSTAINABILITY WITHOUT REQUIRING EFFORT FROM USERS.

The Unconscious Math

If we could design smart home systems to handle this “unconscious math” for users, energy efficiency would happen effortlessly.

Switching Off One Light



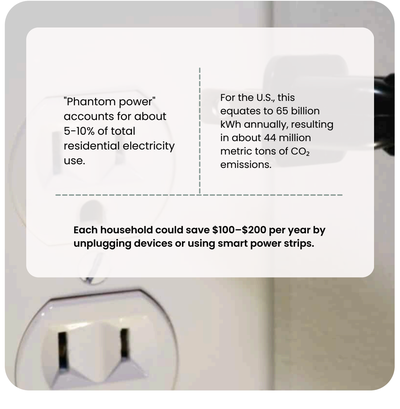
A typical 60-watt incandescent bulb switched off for 4 hours daily saves 87.6 kWh per year (60 W × 4 hours × 365 days ÷ 1,000).

At the average U.S. electricity rate of $0.16/kWh, this translates to about $14 annually per bulb.

If powered by fossil fuels, this equates to saving approximately 68 kg (150 lbs) of CO_2 annually.

Scale-Up Potential:
If every U.S. household (122 million) adopted this practice, it could collectively save 10.7 billion kWh annually, reducing CO_2 emissions by 8.4 million metric tons **(equivalent to taking 1.8 million cars off the road).**

Unplugging Idle Electronics ("Phantom Power")

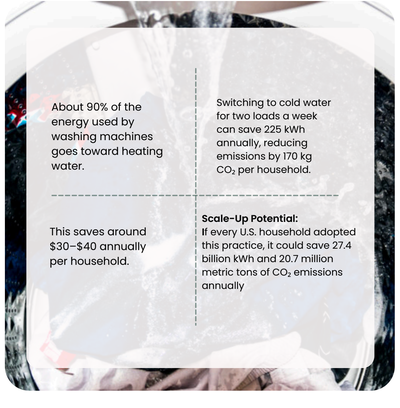


"Phantom power" accounts for about 5-10% of total residential electricity use.

For the U.S., this equates to 65 billion kWh annually, resulting in about 44 million metric tons of CO_2 emissions.

Each household could save $100–$200 per year by unplugging devices or using smart power strips.

Using Cold Water for Laundry



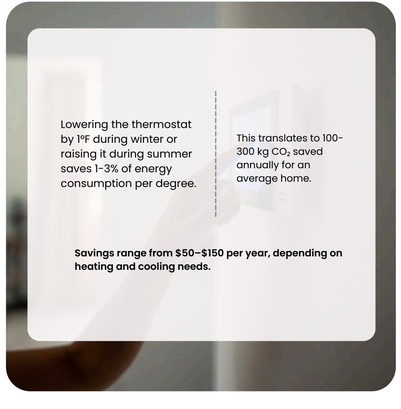
About 90% of the energy used by washing machines goes toward heating water.

Switching to cold water for two loads a week can save 225 kWh annually, reducing emissions by 170 kg CO_2 per household.

This saves around $30–$40 annually per household.

Scale-Up Potential:
If every U.S. household adopted this practice, it could save 27.4 billion kWh and 20.7 million metric tons of CO_2 emissions annually

Adjusting Thermostat Settings



Lowering the thermostat by 1ºF during winter or raising it during summer saves 1–3% of energy consumption per degree.

This translates to 100–300 kg CO_2 saved annually for an average home.

Savings range from $50–$150 per year, depending on heating and cooling needs.

This early realization—that small, sustainable actions add up when automated at scale—became the core philosophy of my research. It shaped the way I framed smart homes as sustainability enablers and influenced how I later explored AI-driven automation, energy efficiency, and user adoption barriers.
By making sustainability effortless, smart homes have the potential to drive long-term environmental and financial impact, which became the central goal of my exploration moving forward.

Cumulative Impact of Small Actions

When small sustainable practices are scaled across millions of households, their cumulative impact is immense.

If 50% of U.S. households adopted just three practices—switching off one light, unplugging idle electronics, and using cold water for laundry—they could collectively save:

103 billion kWh annually (enough to power 9.5 million homes for a year).

Reduce emissions by 78 million metric tons of CO_2 (equivalent to planting 1.3 billion trees).

Save $6 billion annually in electricity costs.

CASE STUDIES

For my research on the current state of the smart home market, I selected a range of smart home products, technologies, and protocols that represent various aspects of innovation, market adoption, and industry challenges. These case studies helped me understand how the smart home industry is evolving, which products are leading the market, and what factors influence adoption.

Popular Consumer Devices

These are some of the most widely adopted smart home products, providing insight into consumer preferences, security concerns, and brand loyalty.

01. GOOGLE NEST

Google Nest is a line of smart home products that includes thermostats, security cameras, doorbells, and smoke detectors. The Nest Learning Thermostat is one of its most popular products, designed to learn user habits and adjust temperature settings automatically to save energy.

Strengths:

- High compatibility with various smart home platforms.
- AI-driven energy optimization for efficient heating and cooling.

Weaknesses:

- Limited offline functionality; most features require an internet connection.
- Privacy concerns due to data collection.

Market Presence:
Google Nest dominates the smart thermostat segment, with the global smart thermostat market projected to reach $8.78 billion by 2025.

02. AMAZON ALEXA

Amazon Alexa is a voice-controlled virtual assistant that integrates with smart home devices. It allows users to control lighting, thermostats, security cameras, and more using voice commands.

Strengths:

- Extensive third-party integrations with smart home products.
- Supports automation and routines for convenience.

Weaknesses:
Privacy concerns regarding voice data storage and usage.

Market Presence:
Amazon Alexa is one of the most popular voice assistants, contributing to the global smart speaker market, which is expected to reach $23.3 billion by 2025.

Statista. (2025)

03. APPLE HOMEKIT

Apple HomeKit is a smart home ecosystem designed for Apple users, allowing them to control devices using the Home app or Siri. It focuses on privacy and security.

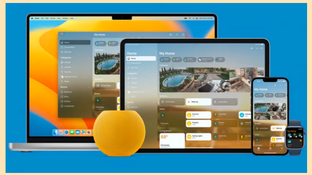
Strengths:

- High level of security and encryption.
- Seamless integration for Apple users.

Weaknesses:
Limited compatibility with non-Apple devices.

Market Presence:
HomeKit contributes to the home automation market, which is projected to reach $63.2 billion by 2025.

Statista. (2024)



Interoperability & Standards

Understanding how different devices communicate and the challenges of compatibility across ecosystems is crucial for future smart home adoption.

04. MATTER PROTOCOL

Matter is an open-source smart home standard developed by Amazon, Apple, Google, and others to ensure device interoperability across platforms.

Strengths:

- Reduces fragmentation in the smart home ecosystem.
- Works with major platforms like Alexa, HomeKit, and Google Home.

Weaknesses:
Still in early adoption; not all devices support it yet.

Market Presence:
Matter aims to unify smart home standards but is still in its early stages of implementation.

The Verge. (2025)

05. ZIGBEE & Z-WAVE

Zigbee and Z-Wave are wireless communication protocols used in smart home devices like lights, locks, and security systems.

Strengths:
- Low-power consumption and reliable connectivity.
- Supports mesh networking for better coverage.

Weaknesses:
Lack of universal compatibility between brands.

Market Presence:
Zigbee and Z-Wave are key players in the home automation market, expected to reach $63.2 billion by 2025.

Tom's Guide. (2025)

Home Automation & AI

AI-driven home automation solutions show how machine learning and voice control are reshaping smart living experiences.

06. SAMSUNG BALLIE ROBOT

Samsung's AI-powered home assistant robot that monitors the home environment and manages smart devices.

Strengths:
AI-driven automation and energy management.

Weaknesses:
Still in concept phase with limited consumer availability.

Market Presence:
Contributes to the household robot market, projected to reach $24.5 billion by 2028.

MarketsandMarkets. (2023).

07. CRESTRON

Crestron is a premium smart home automation system offering custom control for lighting, AV, security, and climate control.

Strengths:
- High-end, customizable automation solutions.

Weaknesses:
Expensive and requires professional installation.

Market Presence:
Contributes to the home automation market, expected to reach $63.2 billion by 202

MarketsandMarkets. (2023).

08. JOSH.AI

With Josh, elegant design seamlessly blends with technology to provide a simplified and secure control platform. Enjoy efficient smart home accessibility with the Josh App or conveniently set the mood with conversational voice commands. Josh knows its role and continues to adapt, enabling users to freely interact with their surroundings and automate their lifestyle in whatever way feels easiest.

Strengths: Privacy-focused AI with natural language processing for seamless smart home control.

Weaknesses: Premium product positioning may limit accessibility for some users.

Fortune Business Insights. (2020)

Energy Management & Sustainability

These case studies helped analyze how smart homes contribute to energy efficiency and sustainable living.

09. NVIDIA'S KITCHEN MANIPULATOR

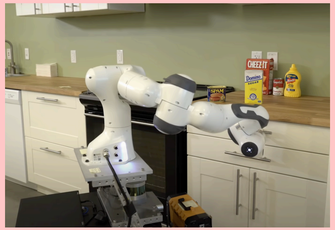
An AI-powered robotic kitchen assistant capable of performing cooking tasks autonomously.

Strengths:
Advanced AI for precision cooking.

Weaknesses:
Expensive and not widely available to consumers.

Market Presence:
Part of the smart kitchen market, expected to reach $32.48 billion by 2025.

Grand View Research. (2023).



10. ECOFLOW'S OASIS SYSTEM

EcoFlow's Oasis is an AI-driven Home Energy Management System that provides real-time monitoring of energy production, storage, and consumption. It utilizes predictive analytics to optimize energy usage, contributing to both environmental sustainability and cost reduction.

Strengths:

- Real-time energy monitoring and sustainability-focused.

Weaknesses:

- High initial costs and dependence on renewable energy.

MarketsandMarkets. (2023).

Future Concepts

Exploring futuristic innovations in shared living, security automation, and robotics reveals where the industry is heading.

11. DESIGN3 CARL ROBOTS

Design3 Carl Robots are autonomous security robots that patrol homes or commercial properties, detecting threats and alerting users.

Strengths:
AI-driven threat detection and real-time surveillance.

Weaknesses:
High cost and privacy concerns.

Market Presence:
The security robot market is projected to reach $44.31 billion by 2030.

Grand View Research. (2024)

IKEA'S SPACE10 "ONE SHARED HOUSE 2030" PROJECT

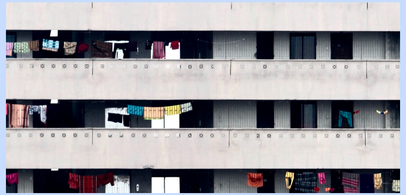
IKEA's external innovation lab, Space10, Shared co-living spaces.

Strengths:
Innovative approach to co-living and sustainable urban living solutions.

Weaknesses:
Conceptual stage with limited real-world implementation.

Market Presence:
As a conceptual project, specific market size data is not available.

IKEA Space10. (2017)



Key Learnings from the Case Studies

- **Adoption varies by region, age, and awareness** – Younger users and developed markets are driving growth, while older demographics and emerging markets show lower adoption due to accessibility challenges.
- **Privacy and security remain a concern** – Users are hesitant about smart home adoption due to data collection practices, cybersecurity risks, and proprietary ecosystems.
- **Interoperability is improving but still a barrier** – The Matter standard aims to unify device compatibility, but widespread adoption is still in progress.
- **Energy management is a growing sector** – Consumers are becoming more interested in AI-driven energy solutions like smart thermostats, automated lighting, and solar-integrated systems.
- **AI and automation are shaping the future** – Smart assistants, robotic home helpers, and predictive home automation are expanding how we interact with living spaces.

By analyzing various aspects of the smart home ecosystem, I have developed a comprehensive understanding of market trends, adoption challenges, and future opportunities. This research has deepened my insights into how technology advancements, consumer behavior, and industry standards shape smart home innovation.

To better categorize my findings, I later divided them into Smart Home Components **(figure 2.3)**, organizing them into a structured table with the following categories:

- Component (The key aspect of smart home technology)
- What It Includes (Devices or technologies within that component)
- Features (Key functionalities and benefits)
- Examples (Leading products or brands in each category)

Components	What it Includes	Features	Examples
Centralized Hub or Controller	Acts as the brain of the system, connecting all smart devices.		Amazon Echo, Google Nest Hub, Apple HomeKit, Samsung SmartThings.
Lighting	Bulbs, switches, or lighting systems that can be controlled remotely or automated.	• Dim or change colors based on preferences. • Automate schedules (e.g., lights turn on at sunset). • Integrate with motion sensors.	Philips Hue, LIFX, Nanoleaf.
Security Systems	Devices focused on home safety and security.	• Smart locks: Lock/unlock doors remotely. • Security cameras: Real-time monitoring and alerts. • Motion sensors: Detect movement and trigger alarms. • Doorbell cameras: Allow two-way communication and video recording.	Ring, Arlo, Nest Secure.
Thermostats and Climate Control	Devices for temperature and air quality control.	• Monitor and adjust temperature remotely. • Use sensors to optimize heating and cooling. • Analyze energy usage to save costs.	Nest Thermostat, Ecobee, Honeywell Lyric.
Appliances	Connected kitchen, laundry, and household appliances.	• Smart refrigerators with inventory tracking. • Ovens that can be preheated remotely. • Washers/dryers that notify you when cycles are complete.	Samsung Smart Fridge, LG ThinQ Washer, Instant Pot Smart Wi-Fi.
Entertainment	Devices for home entertainment that integrate with smart systems.	• Streaming music or video with voice commands. • Multi-room audio systems. • Smart TVs with AI-enhanced recommendations.	Sonos, Roku, Amazon Fire TV, Samsung Smart TV.

Figure 2.3

Components	What it Includes	Features	Examples
Energy Management and Monitoring	Tools for optimizing and tracking energy consumption.	• Smart plugs to monitor device usage. • Solar panel integrations. • Track and analyze energy costs.	Sense Energy Monitor, Wemo Smart Plug.
Sensors	Various sensors that enhance automation and safety.	• Motion sensors to activate devices or lights. • Water leak sensors for flood prevention. • Air quality sensors to detect pollutants.	Aqara Motion Sensor, Wyze Leak Sensor.
Voice Assistants	AI-powered virtual assistants.	• Voice control for all connected devices. • Integration with calendars, reminders, and routines.	Amazon Alexa, Google Assistant, Apple Siri.
Home Ecosystem Integration	Ensures seamless communication between devices from different brands or systems.	• Connects all devices and components together.	• Matter: A standard for interoperability between devices. • IFTTT: A platform for creating custom automations.
Irrigation and Outdoor Systems	Devices for outdoor use.	• Automated sprinklers based on weather data. • Smart outdoor lighting for security and ambiance.	Rachio Smart Sprinkler, Ring Floodlight Cam.
Health and Wellness Devices	Devices focused on personal and family health.	• Sleep trackers. • Smart air purifiers and humidifiers.	Dyson Pure Cool, Withings Sleep Analyzer.
Home Automation Features	Scheduling: Automating routines like turning off lights at bedtime.	Scenes: Pre-configured settings like "movie mode" (dimming lights, closing blinds, and starting a TV).	

Figure 2.3

ECOSYSTEM MAPPING

This ecosystem map **(figure 2.4)** illustrates the relationships between households, smart systems, industry players, regulatory bodies, behavioral experts, and circular economy initiatives in driving sustainable smart home adoption.

Key Elements:

- Households (Green): End-users (renters, professionals, families) adopting smart home solutions.
- Smart Systems (Blue): Platforms like Google Nest, Apple HomeKit, and Amazon Alexa optimize energy use and integrate automation.
- Standards & Regulations (Red): Matter ensures device interoperability, while privacy advocates & legislators address security concerns.
- Influencers & Behavior Designers (Purple): Gamification experts, psychologists, and NGOs promote user engagement in sustainability.
- Infrastructure & Circular Economy (Brown): Includes Tesla Powerwall, utility providers, repair networks, and recycling programs to support long-term energy efficiency.

Why It Matters:

This map highlights how smart systems, behavior-driven incentives, and circular economy initiatives work together to drive sustainable consumer habits in smart homes.

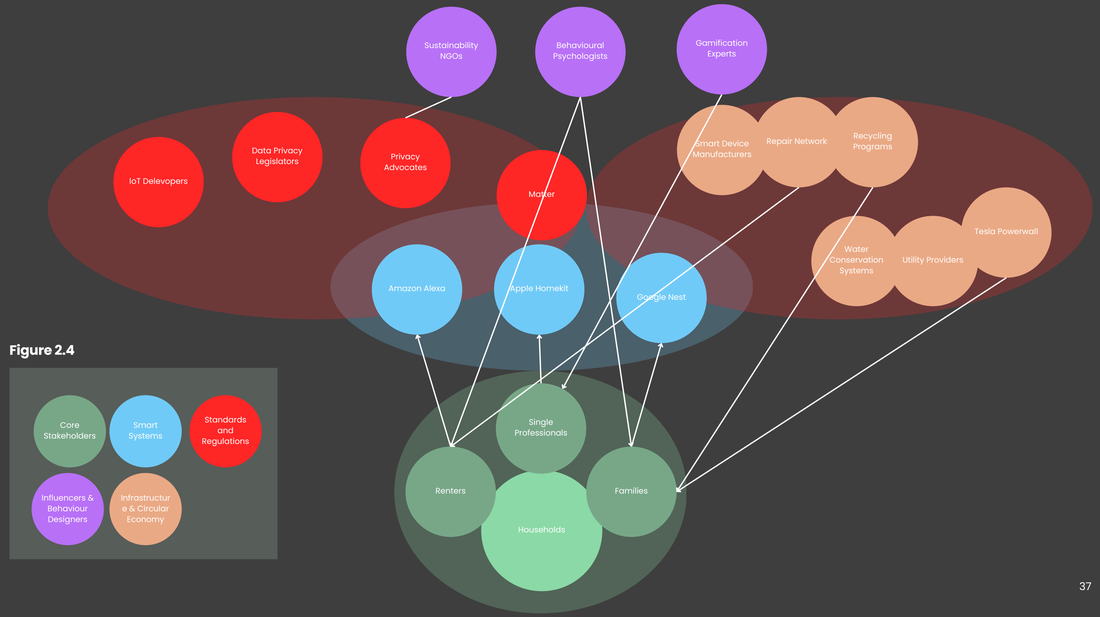
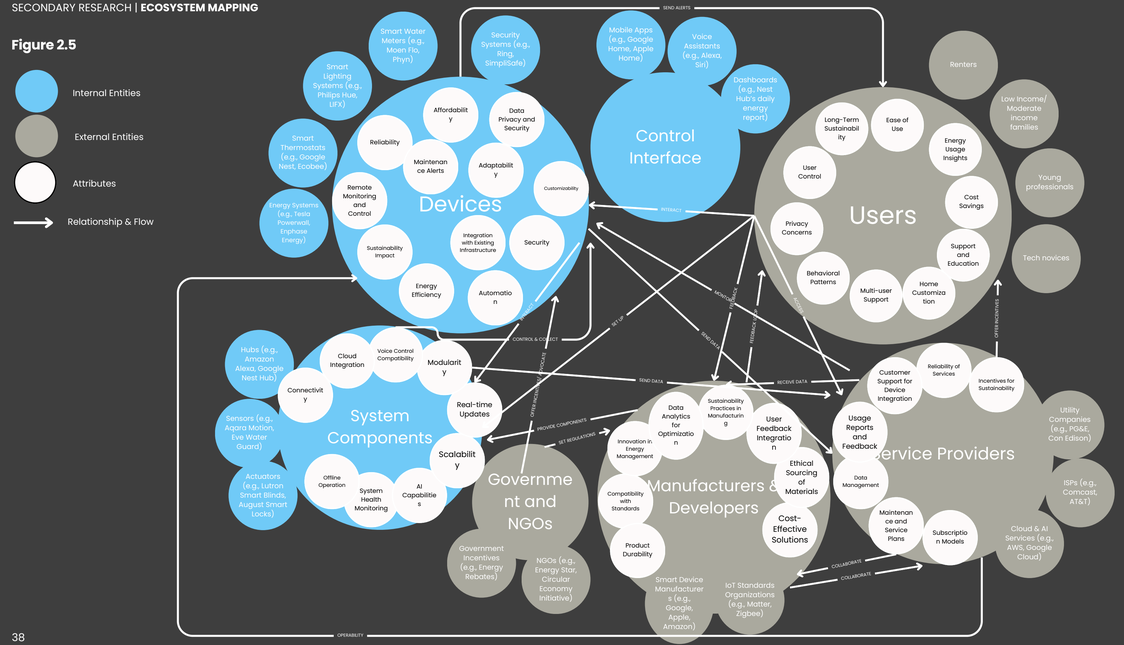


Figure 2.4

Figure 2.5



ERA Framework Ecosystem Map

TThis Ecosystem Relationship-Attribute-Flow (ERAF) Map **(figure 2.5)** illustrates the interactions between smart home users, devices, service providers, manufacturers, and regulatory bodies, highlighting data flows, system attributes, and sustainability considerations.

Key Components:

- Users (Gray): Households (renters, professionals, families) seeking cost savings, privacy, and energy efficiency.
- Devices & Control Interface (Blue): Smart home tech (thermostats, lighting, security, energy systems) with AI-driven automation and real-time monitoring.
- System Components (Blue): Hubs, sensors, and actuators enabling modularity, cloud integration, and energy optimization.
- Manufacturers & Developers (Gray): Tech companies (Google, Apple, Amazon) focus on device compatibility, AI optimization, and sustainable manufacturing.
- Service Providers (Gray): Utility companies, ISPs, and cloud services support connectivity, data management, and sustainability incentives.
- Government & NGOs (Gray): Offer energy rebates, enforce regulations, and promote circular economy initiatives.

Why It Matters::

This map highlights how smart home technology, AI-driven automation, user behavior, and policy incentives interconnect to drive sustainable living. It showcases data flows between stakeholders, emphasizing the role of manufacturers, service providers, and governance in enabling efficient and eco-friendly smart home adoption.

Mind Mapping the Ecosystem of Smart Eco AI Solutions

While developing this mind map **(Figure 2.6)**, I focused on mapping out the key technological, behavioral, and systemic factors that influence sustainability in smart homes. My goal was to identify how AI-driven automation and interoperability can drive energy efficiency, encourage sustainable behaviors, and integrate with larger policy and financial incentives.

Key Areas I Explored:

AI-Powered Home Automation (Blue):

- I wanted to understand how energy management, water conservation, and waste reduction can be automated through smart systems. Brands like Nest (Google), Ecobee, and Moen are already driving innovation in this space, and I explored how monitoring, predictive AI, and automation optimize sustainability without requiring constant user intervention.

Device Interoperability (Teal):

- One major challenge I noticed in smart home ecosystems is fragmentation—different brands and platforms operate in silos. Matter protocol, Zigbee, and cloud-based integrations are bridging this gap, and I explored how interoperability can make smart home solutions seamless and accessible to users.

Sustainable Behaviors & Financial Incentives (Orange & Purple):

- While automation is powerful, behavioral nudges (like energy tracking apps & gamification) play a crucial role in motivating long-term engagement. I explored how tax credits, rebates, and dynamic energy pricing could make sustainable choices financially beneficial for users.

Challenges (Red) & Opportunities (Blue-Green):

- Privacy concerns, high initial costs, and ecosystem fragmentation remain barriers to adoption. However, I discovered that partnerships with utilities, government programs, and blockchain-based energy credit tracking offer scalable solutions to these challenges.

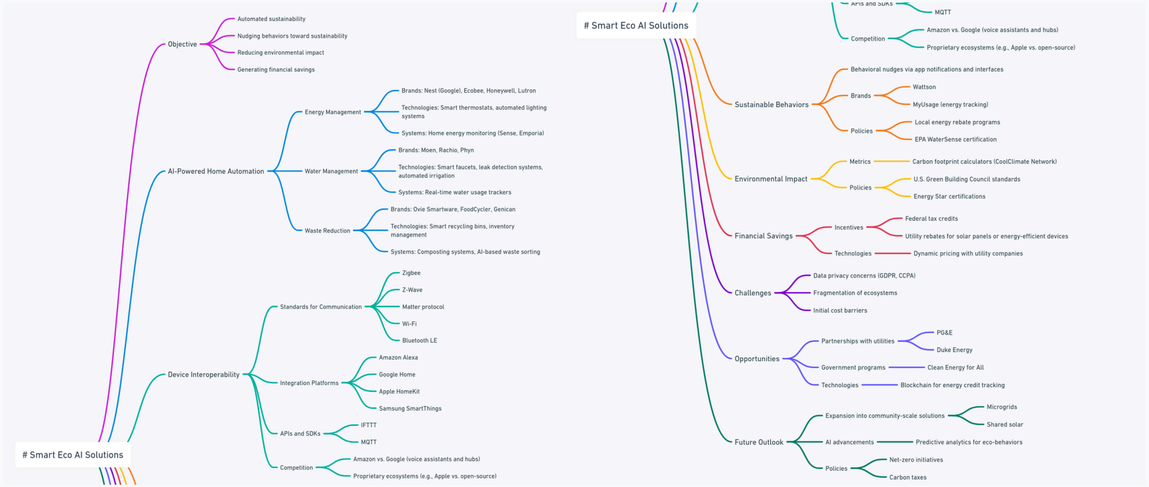
Future Outlook (Green):

- I envisioned a long-term future where AI-driven smart home solutions scale beyond individual households to community-wide microgrids and shared solar networks. AI advancements in predictive analytics for eco-behaviors and policy shifts (carbon taxes, net-zero initiatives) could accelerate adoption globally.

Why This Mind Map Was Important to My Project:

Creating this map helped me connect individual smart home technologies with larger sustainability goals. It reinforced that AI and automation alone are not enough—behavioral nudges, financial incentives, and regulatory support must work together to drive adoption.

Figure 2.6



EMERGING TECHNOLOGIES

After analyzing current smart home technologies, reviewing case studies, and developing an ecosystem map, I gained a comprehensive understanding of the existing smart home landscape. This deep dive helped me see what smart homes currently consist of and how they function within larger systems.

With this foundation, I shifted my focus to emerging and cutting-edge technologies that have the potential to transform smart homes in the next five years. This phase of research was extensive and time-consuming due to the sheer volume of experimental innovations and future concepts in the field.

To narrow my scope, I naturally branched into two distinct directions, which I categorized as Phase 1 and Phase 2. These phases represent different trajectories for the evolution of smart homes, and I have elaborated on them further in my process book.

This structured approach allowed me to balance an understanding of current technologies while exploring future possibilities, ensuring that my research remains both grounded and forward-thinking.

01. Decentralized Energy Systems: Tesla Powerwall and Virtual Power Plants

Tesla's Powerwall is a home battery system that stores energy from solar panels or the grid, enabling households to manage their energy usage effectively. When integrated into a network, these systems form a Virtual Power Plant (VPP), allowing energy sharing within a community and reducing dependence on centralized power grids.

Relevance: This case demonstrates how decentralized energy systems can empower homeowners, promote renewable energy adoption, and contribute to grid resilience.

Case Study: South Australia's Virtual Power Plant

- Implementation: Initiated in 2018, Tesla partnered with the South Australian government to equip homes with solar panels and Powerwall batteries, creating a large-scale VPP.
- Scale: As of 2024, approximately 7,000 homes have been integrated, contributing 35 megawatts (MW) of energy capacity.
- Impact: Participants benefit from reduced energy costs, and the VPP enhances grid stability by supplying excess energy during peak demand.

News.com.au. (2024, January 15)

01. AI-Driven Personalization: Ecobee Smart Thermostats

Ecobee offers smart thermostats equipped with AI capabilities that learn user preferences and adapt heating and cooling schedules accordingly, optimizing energy consumption without compromising comfort.

Relevance: This case demonstrates how decentralized energy systems can empower homeowners, promote renewable energy adoption, and contribute to grid resilience.

Case Study: Energy Savings through AI Optimization

- **Implementation:** Ecobee's thermostats utilize machine learning algorithms to analyze occupancy patterns and adjust climate control settings in real-time.
- **Impact:** Studies have shown that users can achieve up to 23% savings on heating and cooling costs.
- **Collaboration:** Ecobee collaborates with the U.S. Environmental Protection Agency (EPA) to enhance the ENERGY STAR thermostat certification, utilizing data insights to improve energy efficiency standards.

Ecobee. (2024)

The future of smart homes

This section **(figure 2.7)** explores how emerging technologies, AI-driven automation, and sustainable solutions will shape the evolution of smart homes over the next five years. It highlights advancements in AIoT, energy efficiency, infrastructure, privacy, and robotics, showcasing how homes will become more intelligent, efficient, and self-sustaining.

How This Informs My Process:

This research provides a future-forward perspective on smart homes, helping me:

- Define key technological trends that influence smart home evolution
- Understand the role of AI, sustainability, and automation in long-term home innovation.
- Identify opportunities for integrating emerging technologies into my project.

By considering AI-driven automation, decentralized energy grids, and sustainable home design, I

Figure 2.7

	Changes	Features
Rise of the Artificial Intelligence of Things (AIoT)	Behavioural and context driven. Complete automation and little intervention of human direction.	• Improved security — technology can distinguish pets and robot vacuum cleaners from human motion, and differentiate occupants and family members from intruders • Health and wellbeing insights — predictive analytics can look at deviating activity patterns for indicators of health problems in need of addressing. As a reactive measure, falls or other accidents might be detected in the same way, and family members of emergency services notified. • Enhanced comfort — the home can learn lighting and heating preferences, and automatically adjust settings for the occupant's preferences. • Data analytics provide actionable insights • Personalized comfort settings: future smart home systems will be able to provide personalized environmental adjustment services based on the preferences of each family member, including temperature, light, sound, and other aspects. For example, AI can automatically remember the user's work and rest habits and adjust the brightness of the room's lights or the stereo's volume at a specific time.
Efficient energy and resource use	From a 'linear' model of energy consumption, where energy is simply wasted where an appliance or device is not being used (standby mode), to a 'circular' model where energy is only used as absolutely required.	• Enhanced energy conservation in appliances —through analysis of occupancy and motion, HVAC and other appliances can be powered up and down, automatically. • Smart meter integration, which will allow energy charges and tariffs to be more carefully tailored to actual energy use in the home, and incentivize occupants to consume energy more carefully. • Full connectivity between solar PV, other renewable energy sources, batteries, and smart home infrastructure. This will allow individuals to more carefully manage their energy use to move towards a 'zero net energy' outcome. In some cases, the increased inefficiency may even allow the smart home to become a 'net energy generator', as excess electricity generation is fed back into the network • Digital sensors to better monitor and manage grey water and biowaste within the home, minimizing the pressure placed on external water and sewerage infrastructure.
Improved physical infrastructure		• An increase in the use of sustainable and recycled materials in construction. This is driven both by legislation, as well as consumer choice, as people become more aware of the environmental impact of construction. • A move away from the traditional 'grid' layout of electrical wiring and plumbing, to a more modular and flexible design. This will allow for easier installation and maintenance of smart home systems, as well as future-proofing the home against changes in technology. • A move towards modular construction, where homes are built from prefabricated modules which can be easily added or removed as required. This will allow homeowners to more easily adapt their homes to changing needs, such as aging in place, or accommodating a growing family. • **The growth of 'smart tiny homes'. As housing and energy costs continue to soar, and environmental concerns drive consumer choice for more sustainable housing options, expect to see smart home technology designed specifically for the tiny home.**

Figure 2.7

	Features
Voice Control Technology Becomes Smarter	• Natural Language Processing (NLP) is further enhanced: future voice assistants will be able to interact with people more naturally, no longer limited to simple command-based conversations, but able to understand more complex and multi-step requests. The communication between the user and the voice assistant will be closer to a human-to-human conversation, reducing operational barriers. • Better context-awareness: voice assistants are not only able to handle single tasks but also understand and process multi-step commands through contextual information. For example, when a user asks to dim the lights, the assistant can understand that this could be in preparation for a movie and automatically adjust other devices in the home, such as closing the curtains or changing the air conditioning temperature. • More Accurate Voice Recognition: Future voice assistants will have stronger voice recognition capabilities and can recognize the voices of different family members to provide personalized services. For example, the assistant can determine whether a parent or a child is speaking based on the voice and configure the appropriate operation scheme according to different users. • Broader device integration: the smart home of 2025 will enable more devices to be interconnected, from kitchen appliances to bedroom furniture, and voice assistants will serve as the core control platform for devices in the home, allowing users to manage the entire home system through voice commands.
Advanced display technologies	• Transparent OLED Screen: Transparent OLED display technology will enable screens to be embedded into windows, mirrors, and other household items, providing the desired information display function without additional space. For example, users can view weather forecasts or schedules through mirrors without additional display devices. • Holographic Display: Holographic display technology will make the visualization of 3D data and content more vivid and intuitive. Holographic displays can provide an immersive viewing experience in home entertainment or design. They can even be used to preview 3D models for interior design. • Augmented Reality (AR) Overlay: With AR technology, users can overlay virtual information on natural scenes through augmented reality glasses or cell phones. For example, users can see a virtual arrangement of furniture in their home or instructions and maintenance advice for appliances via their cell phones. • Flexible and rollable screens: Future displays will be more flexible and can be rolled up or hidden to save space when not needed by the user. For example, displays in the home can be rolled up and hidden within furniture, only revealing themselves when required.
Sustainable and Energy Efficient Homes	• Advanced energy management systems: Energy management systems in smart homes will become more intelligent and automated. These systems will automatically adjust the working hours of appliances by analyzing the household's electricity demand and energy supply. For example, high-powered appliances such as washing machines and dryers can be scheduled to run during periods of low peak electricity consumption in response to fluctuations in electricity prices, thereby reducing energy costs and carbon footprints. • Integration with renewable energy: Smart homes will be closely integrated with renewable energy systems, especially solar and wind energy. Homes can be fitted with solar panels or micro-wind turbines, and smart systems can automatically manage energy generation and storage. Energy management systems in the home can store excess energy in batteries or share it with the grid for optimal energy allocation based on real-time demand and weather conditions. • Smart Water Management: With the increasing shortage of water resources, smart home technology will play an important role in water conservation and management. Smart water meters of the future will be able to detect leaks and issue timely alerts to avoid water wastage. In addition, the system can optimize the time spent watering plants or lawns according to the family's water habits and weather conditions, reducing unnecessary water consumption. • Automated Waste Recycling System: Waste sorting and recycling will become more intelligent and convenient. Smart home systems can be equipped with automated waste sorting equipment that can automatically recognize different types of waste and sort them out. They can even help users sort and store recyclable materials, thus reducing the negative impact on the environment.

Figure 2.7

	Features
Privacy and security enhancements	• Enhanced encryption and security protocols: smart home devices will utilize more sophisticated encryption techniques to secure data transmission between home networks and devices. For example, all devices connected to the home Wi-Fi network will use robust encryption algorithms to prevent hacking and data leakage. In addition, communication between smart devices will be secured through multiple authentication mechanisms. • Finer control over data sharing: Users can exercise finer control over the data in their smart home devices, deciding what data can be shared with third parties and what data should be kept entirely private. Future smart home platforms will allow users to freely set the privacy level of each device through a simple and intuitive interface and even have the option to delete historical data collected by the device automatically. • Widespread application of biometrics: To further protect home security, biometrics will be widely used in the smart home. In the future, users can access sensitive systems in the home, such as home security systems or financial management systems, through fingerprints, facial recognition, voice recognition, etc., ensuring that only authorized personnel can control critical equipment. • AI-driven threat detection: artificial intelligence will be an important part of future smart home security systems. AI will be able to monitor network activity between devices, automatically detect potential cyber-attacks or unusual behavior, and proactively block threats before they occur. For example, the system can detect unfamiliar devices trying to connect to the home network or unusual operating behavior and automatically take steps to protect against it.
Robotic Assistants and Automation	• Advanced Cleaning Robot: future cleaning robots will have stronger navigation and object recognition capabilities to cope with complex home environments easily. The robot can automatically recognize obstacles through AI technology and intelligently plan cleaning routes to ensure every corner is cleaned. In addition, the robot can recognize different types of stains and choose the appropriate cleaning method to enhance efficiency. • Kitchen robot assistant: The kitchen will become a key scene for robot applications in the future smart home. Robot assistants can assist users in the entire process, from food preparation to cooking. For example, the robot can automatically cut vegetable seasoning and even operate kitchen utensils for cooking, thus greatly reducing the user's workload. This intelligent kitchen assistant will greatly enhance cooking efficiency for busy modern families. • Personal care robots: Future personal care robots will help the elderly or disabled. The robots can assist users in completing some basic activities in daily life, such as bathing, dressing, eating, etc., to help them maintain the ability to live independently. At the same time, these robots can also monitor the user's physical condition through sensors and provide timely health advice or emergency assistance. • Modular robots: Modular robots can configure themselves according to the tasks' needs. For example, the robot can be converted into a vacuuming mode when cleaning the home, and it can be reconfigured as a moving tool when it needs to carry items. This flexible design will greatly expand the robot's application scenarios and enhance its utility.

IEEE Xplore. (2024). Investigating & uncovering the future of smart residential automation.
Springer. (2023). Changing world: Smart homes review and future
Springer. (2024). A taxonomy of home automation: Expert perspectives on the future. Information Systems Frontiers.
IEEE Xplore. (2022). Smart homes powered by machine learning: A review.
IEEE Xplore. (2024). The impact of smart homes on energy efficiency and sustainability.

To summarise it:

Full Integration of Artificial Intelligence (AI)	• AI-driven homes will anticipate and meet user needs through advanced machine learning. • Smart homes will autonomously adjust settings based on user habits and routines. • AI will enhance personalization, making homes more intuitive and user-friendly.
Reliable Connectivity & Powerful Systems	• Faster, more stable internet connections will eliminate delays and disruptions. • Improved system responsiveness will enable seamless device interactions. • Surveillance systems will offer high-resolution, low-light visibility. • Instant, buffer-free streaming and flawless voice assistant communication.
Enhanced & Greater Security	• AI-powered security systems will offer precise, reliable user recognition. • Biometric and behavioral recognition will replace traditional passwords. • Smart surveillance drones will provide real-time security monitoring.
Audio & Video Interactivity	• Advanced telepresence through holograms & augmented reality (AR) for remote work. • AI-driven entertainment systems will deliver immersive and personalized experiences. • High-realism video conferencing will enhance remote collaboration.
Integration of Wearable Devices	• Smart wearables will track occupants' health and adjust home settings accordingly. • Personalized environmental control based on real-time biometric data. • Seamless synchronization with smart home systems for enhanced convenience.
Expansion of Contactless & Gesture-Based Technology	• Voice and gesture commands will replace manual interactions. • Smart surfaces will enable touch-free control of appliances and settings. • AI will enhance automation for an effortless, touchless user experience.
Smarter & More Energy-Efficient Homes	• AI-optimized energy management will reduce consumption and lower costs. • Smart grids and IoT-connected devices will optimize power usage. • Self-sustaining homes with renewable energy integration will become more common.
Home Automation as a Fully Integrated Ecosystem	• Smart homes will shift from a collection of devices to a seamless, adaptive ecosystem. • AI, IoT, and automation will work in synergy to optimize home environments. • Future smart homes will bring unparalleled comfort, safety, and efficiency.

LITERATURE REVIEW

Conducting this literature review was essential to building a solid foundation for my research. It helped me understand the existing knowledge base, identify key trends, and refine my focus on how AI and automation contribute to sustainable behavior in smart homes.

01. AI's Role in Behavior Modification for Sustainability

Key Insight:

AI influences unconscious behaviors by automating repetitive tasks, nudging users towards eco-friendly actions, and learning from user patterns.

Behavioral nudges like real-time feedback (energy dashboards) reinforce eco-friendly habits.

Supporting Study:

- "The Role of AI in Sustainable Behavior Change," IEEE Xplore, highlights how AI can implement and sustain small-scale, unconscious actions in daily life.
- AI's ability to adapt user preferences creates habit-forming loops for sustainability.

Why I Studied This: AI plays a critical role in shaping user behavior by reinforcing eco-friendly habits through automation and real-time feedback.

How It Helped Me: It validated the idea that small, automated nudges (like energy dashboards and smart scheduling) can create long-term sustainability habits. This reinforced the importance of AI-driven personalization in my project.

Nest. Energy Impact Report. (2024)

02. Economic and Environmental Impacts of Automated Sustainable Practices

Economic Impact:

- Smart thermostats alone can save U.S. households $120–$150 annually on energy.
- Water efficiency systems like Moen Flo reduce water bills by 10-15% annually.

Environmental Impact:

- Automated leak detection in water systems saves billions of gallons of water annually (Source: Moen Report).
- Smart lighting systems reduce CO_2 emissions by an estimated 500 pounds per household per year.

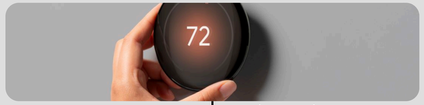
Supporting Study:
"Quantifying Environmental Benefits of Smart Home Technology," Springer, showcases long-term ecological benefits of automation in homes.

Why I Studied This: I needed quantifiable evidence of how smart home automation contributes to both financial savings and environmental benefits.

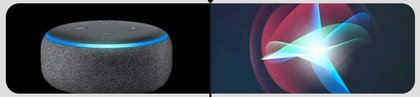
How It Helped Me: The data (e.g., 15% energy savings with Nest, 10-15% water savings with Moen Flo) gave me real-world statistics to support my design interventions. This strengthened my case for integrating AI-driven efficiency into smart homes.

Moen. Water Efficiency Impact Study: Moen Flo.

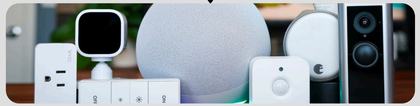
03. Historical Evolution of Smart Home Ecosystems



2010: Emergence of smart thermostats (e.g., Nest).



2015: Integration of voice assistants (e.g., Alexa, Siri).



2022+: Focus on sustainability with protocols like Matter and AI-powered efficiency.

Early systems focused on convenience and luxury, evolving into sustainability-driven ecosystems.

Why I Studied This:
Understanding the timeline of smart home advancements helped me trace the shift from luxury-driven automation to sustainability-focused solutions.

How It Helped Me: It highlighted the growing role of AI, IoT, and interoperability protocols (like Matter) in pushing smart homes toward circular and energy-efficient systems. This gave me a clearer roadmap for predicting future trends.

Nest. Energy Impact Report. (2024)

How These Literature Reviews Shaped My Next Steps:

- **Refined My Focus:** I narrowed my research into to potential phases rather than just general smart home technology.
- **Strengthened My Justification:** The evidence-backed economic and environmental impact data gave me a stronger argument for why my solutions matter.
- **Helped Me Identify Gaps:** I realized there's still a lack of user-centric sustainability metrics in smart homes, which I could explore in my project.

Two Potential Project Directions.

Earlier in the project, I started by exploring Smart Home Adoption, particularly the sociocultural dynamics that influence it. My research covered consumer benefits, barriers to adoption, and behavioral patterns, leading me to formulate a Concept Map of Critical Analysis and even create a future case study envisioning my own perspective on smart home evolution.

However, I soon realized that my approach was still too broad and lacked a focused, actionable angle for real-world impact. The challenge was that:

- Smart Home Adoption is a vast subject influenced by social, economic, and psychological factors, making it difficult to narrow down a tangible design intervention.
- While understanding adoption trends is valuable, it didn't give me a clear framework to integrate my expertise in Service Design and Sustainability into a direct solution.

This realization led me to diverge into a new research direction: Smart Technologies in Conjunction with Energy Saving & Comfort in a Home Environment.

Why This New Focus Works Better

This shift allowed me to narrow my scope while still making a significant impact in sustainability and user experience.

- "Energy Saving" aligns directly with sustainability strategies, allowing me to explore AI-driven efficiency, renewable energy integration, and decentralized grids.
- "Comfort" refers to how smart homes can seamlessly adapt to user patterns and preferences, creating an effortless living experience.

  It involves anticipatory AI, where technology learns from behavior and automates functions like lighting, temperature, and security.

  It ensures that the smart home is not just energy-efficient but also enhances the quality of life through intuitive, responsive environments.

How This Aligns with My Skillset

By focusing on Smart Technologies for Energy & Comfort, I found an opportunity to leverage both of my skillsets:

Service Design – I can create user-centered solutions that make smart home sustainability accessible and engaging.

Sustainable Strategies – I can integrate circular systems, energy optimization models, and behavioral interventions for long-term impact.

PHASE ONE:

SOCIOCULTURAL DYNAMICS OF SMART HOME ADOPTION

This section highlights everything I explored about sociocultural dynamics through reviewed papers **(figure 2.8)** in smart home adoption, including consumer behavior, adoption barriers, and societal influences. This phase was integral to my project as it provided a strong foundation for my Phase Two research on Smart Technologies in Conjunction with Energy Saving & Comfort.

Figure 2.8

MAIN RESEARCH REPORTS

- **Author: Leeladhar Ganvir, Research Scholar IGI Global Article Ganvir, L., & Kalita, C. P. (2022).** Adoption of Socio-Cultural Aspects in PSS Design for Smart Home Products: An Integrative Review. Archives of Design Research, 35(4), 7-29.
- **Author: Ajibade Adebayo Research Gate Adebayo, A., & Egba, C. (2020).** The impact of smart home technology adoption on user behavior and societal change. Technological Forecasting and Social Change, 157, 120-135. https://doi.org/10.1016/j.techfore.2020.120775
- **Author: Orioli Luke IEEE Xplore Luke, O. (2018).** The role of socio-technical systems in the adoption of smart home technologies: A critical review. STS Research Paper. Retrieved from file:///Users/52482/Downloads/Orioli_Luke_STS_Research_Paper.pdf
- **Author: Rogers Winston Research Gate Rogers, W., & Smith, T. (2018).** Barriers to adoption of smart home technology: A sociocultural perspective. Technological Forecasting and Social Change, 136, 102-112. https://doi.org/10.1016/j.techfore.2018.07.123
- **Author: Markus Fuchs Springer Fuchs, M., & Müller, L. (2020).** The dynamics of smart home adoption: Insights from user-centric studies. Information Systems Frontiers, 22(4), 921-941. https://doi.org/10.1007/s10796-020-10042-3
- **Author: Daniel Perera AIS Electronic Library Perera, D., & Hassan, R. (2019).** Exploring sociocultural influences on the adoption of smart home technology. Proceedings of the UK Academy for Information Systems Conference 2019. Retrieved from https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1065&context=ukais2019

Through my research , I explored how sociocultural factors influence smart home adoption **(figure 2.9)** and how Product-Service Systems (PSS) could provide a more user-centered approach to smart home design.

Key Insights & Relevance to My Process:

- **Product-Service Systems (PSS) & Smart Homes**
  - PSS integrates tangible products with intangible services to meet real consumer needs. However, smart home development has been largely technology-driven, rather than focused on user experience or cultural adaptability.
  - **Relevance**: This showed me that for smart homes to be truly seamless and widely adopted, they must be designed with user behavior, emotional connection, and real-world needs in mind.

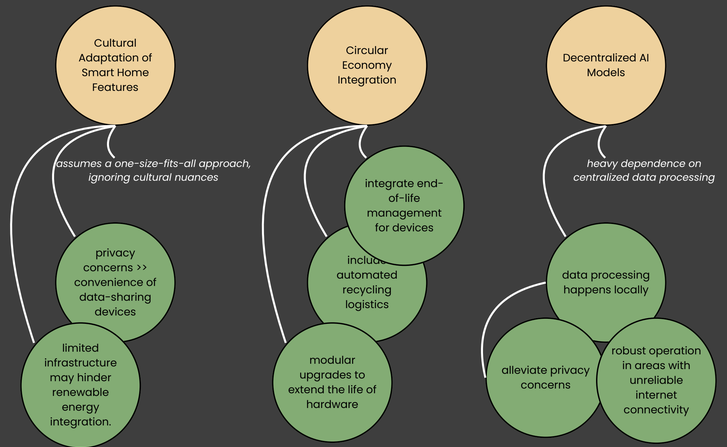
Cultural Differences in Smart Home Adoption

- Studies show that trust is the primary factor in smart home acceptance, as seen in the USA and Japan.
- Example: In Japan, users develop emotional attachments to robots, even conducting funerals for obsolete devices (James, 2018). This highlights how emotional connection and trust influence technology adoption.
- **Relevance**: This reinforced the idea that smart home solutions must be intuitive, human-centered, and culturally adaptable to increase adoption rates.

Lack of Research on Cultural Differences in Smart Home Adoption

- While many studies focus on technical innovations, there is limited research on how cultural norms and demographics influence adoption behaviors (Lee et al., 2020).
- **Relevance**: This gap in research pushed me to consider how different user demographics approach smart homes and how behavioral insights could inform smarter, more inclusive solutions.

Figure 2.9



Consumer benefits

Understanding why people adopt smart home technology reinforced my decision to focus on energy and comfort in smart homes, ensuring that sustainability efforts also improve user experience rather than just reducing resource consumption.

	Consumer Benefits	Themes	Sources	No. of sources
1	Health-related benefits	• Promoting well-being of aging and vulnerable people • Care accessibility and comfort • Monitoring user's safety • Consultancy for social connectivity and communication • Supporting detection of life-threatening events • Therapy for the reduction of medical errors	Chan et al., 2008; Demiris et al., 2008; Demiris & Hensel, 2009; Reeder et al., 2013; Courtney et al., 2008; Rantz et al., 2005; Finkelstein et al., 2004; Czaja, 2016; Mynatt et al., 2004; Walsh & Callan, 2011; Cavicchi & Vagnoni, 2017; Rahimpour et al., 2008; Matlabi et al., 2012; Kerbler, 2013	14
2	Environmental benefits	• Environmental sustainability • Monitoring and reducing energy usage • Consultancy and feedback on energy and resource consumption • Suggestions on how to use electricity efficiently and comfortably	Balta-Ozkan et al., 2014; Chen et al., 2017; Elkhorchani & Grayaa, 2016; Zhou et al., 2016; Kyriakopoulos & Arabatzis, 2016; Kiesling, 2016; Aye & Fujiwara, 2014; Paetz et al., 2011; Paetz et al., 2012; Yang et al., 2017; Ellen MacArthur Foundation, 2023; Geissdoerfer et al., 2017	11
3	Financial benefits	• Affordability of health care • Sustainable consumption • Cheaper consultancy and monitoring costs of virtual visits	Balta-Ozkan et al., 2013a; Darby & McKenna, 2012; Faruqui et al., 2010; Steele et al., 2009; Ehrenhard et al., 2014; Kun, 2001; Anderson, 2007; Bocken et al., 2016	8
4	Psychological well-being and social inclusion	• Overcoming the feeling of isolation • Support • Entertainment • Virtual interaction	Percival & Hanson, 2006; Brandt et al., 2011; Gaul & Ziefle, 2009; Kim et al., 2013; Balta-Ozkan et al., 2013b; Khedekar et al., 2017.	6

Figure 2.10

Consumer Barriers

While researching consumer barriers **(figure 2.11)**, I realized that for smart homes to be truly impactful, they must be designed with simplicity, security, and user trust in mind. This reinforced my shift toward Smart Technologies for Energy & Comfort, where AI-driven systems should be intuitive, seamless, and non-intrusive to encourage adoption.

Sr. No	Consumer Barriers	Themes	Sources	No. of sources
1	Technological barriers	• Security • Usability • Privacy intrusion • Reliability	Balta-Ozkan et al., 2013a; Park et al., 2018; Alsulami & Atkins, 2016; Czaja, 2016; Diegel, 2005; Kim & Shcherbakova, 2011.	6
2	Financial, ethical, and legal barriers	• Price • Cost of installation • Cost of repair and maintenance • Concern about misuse of private data	Balta-Ozkan et al., 2013a; Steele et al., 2009; Chan et al., 2012; Wells, 2003; Friedewald et al., 2005; Kotz et al., 2009; Coughlan et al., 2013; Lorenzen-Huber et al., 2011; Chan & Perrig, 2003; Chiang & Wang, 2016.	9
3	Knowledge gap and psychological resistance	• Human barrier • Resistance to using innovative technology • Lack of prior knowledge and/or experience	Kerbler, 2013; Mani & Chouk, 2017; Ram & Sheth, 1989; Kleinberger et al., 2007; Fuchsberger, 2008; Stringer et al., 2013; Edwards & Grinter, 2001; Wu & Fu, 2012; Meng & Lee, 2006; Stahel, 2016	9
4	User-centric research of smart home products	• User perception of smart home technology • Demographics and geographic change • Smart home technology benefits for users • Focus on the aging population	Chen et al., 2017; Bhati et al., 2017; Stringer et al., 2006; Wu & Fu, 2012; Chiang & Wang, 2016; Courtney et al., 2008; Yamazaki, 2006; Vilas et al., 2010; Ganvir, L., & Kalita, C. P., 2022; Adebayo, A., & Egba, C., 2020, Fuchs, M., & Müller, L., 2020	11
5	Smart home acceptance and adoption	Smart home technology acceptance factors	Dawid et al., 2017; Khedekar et al., 2017; Peetoom et al., 2015; Ehrenhard et al., 2014; Balta-Ozkan et al., 2013b; Park et al., 2018; Yang et al., 2017; Alsulami & Atkins, 2016; Mani & Chouk, 2017; Chung et al., 2016; Rogers, W., & Smith, T., 2018; Perera, D., & Hassan, R.,2019;	11

Figure 2.11

Concept Map of the Critical Analysis

As part of my research on smart home adoption, I explored IoT products, user needs, adoption factors, and sociocultural influences. This helped me analyze smart home products not just from a technological perspective, but also from a behavioral and user-centric standpoint **(figure 2.12).**

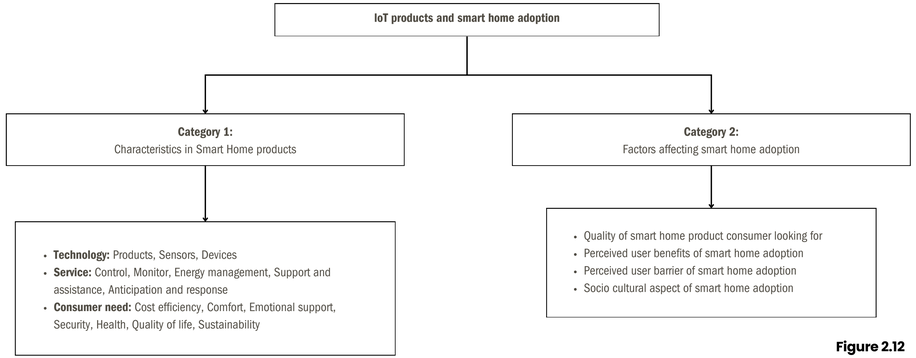
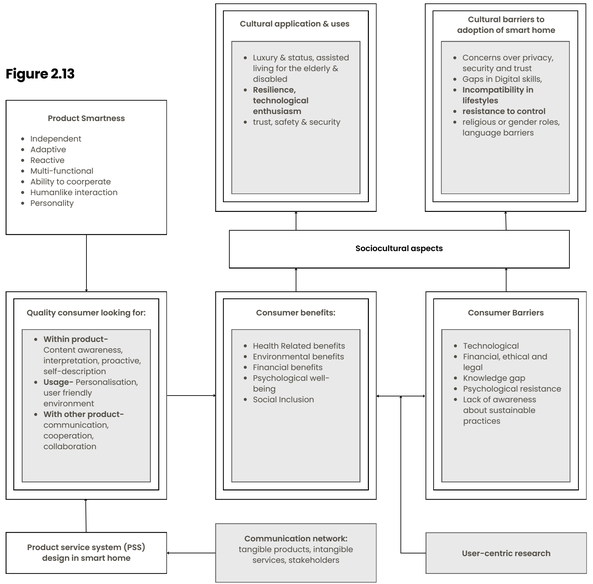


Figure 2.12

conceptual framework for factors affecting consumer's new technology acceptance.

This conceptual framework **(figure 2.13)** provides a comprehensive structure for analyzing smart home adoption and resistance factors. It emphasizes that successful smart home solutions must balance technology, user needs, sociocultural context, and trust-building mechanisms to ensure widespread acceptance and long-term engagement.

Figure 2.13



Case Study: The Future of Smart Home Systems in 5 Years

Vision:
In the next five years, smart home systems will evolve into fully integrated ecosystems driven by the Artificial Intelligence of Things (AIoT). These homes will anticipate user needs through contextual learning and dynamic automation, blending sustainability, convenience, and security.

Key advancements:
Personalized Automation
Homes will use AI to learn routines, preferences, and environmental conditions to optimize energy use, security, and comfort.

Interoperability Standards
Protocols like Matter will enable seamless communication between devices from different brands.

Energy Efficiency and Sustainability
Smart homes will integrate renewable energy sources, advanced energy storage, and resource management systems, creating net-zero or energy-positive homes.

Augmented Reality (AR) Interfaces
AR overlays on transparent OLED screens and holographic displays will revolutionize how users interact with their environments.

Health and Wellness Integration
Smart systems will monitor health patterns, detect emergencies, and provide predictive analytics for well-being.

Hidden opportunity:
- Encouraging users to perform actions like switching to renewable energy or conserving water with in-app challenges.
- Offering rewards for using energy during off-peak hours or recycling smart home components through certified programs.

Forming a Link Between Smart Homes and the PSS Approach

Shift to User-Centric Design:
- Ethnographic research and user personas to map consumer pain points in their living spaces.

Integrating Stakeholders:
- Involve multiple stakeholders (manufacturers, service providers, users, and policy-makers) to co-create solutions.

Blending Tangibles and Intangibles:
- Design products that are modular and adaptive to evolving consumer needs.

Service Design Thinking:
- Apply service design tools like journey mapping and ecosystem mapping to identify touchpoints where a PSS approach can add value.
- Create service blueprints that outline the interaction between products, services, and stakeholders.

Lifecycle Thinking:
- Design for the entire product lifecycle, focusing on repairability, upgrades, and recycling.
- Integrate circular economy principles to ensure sustainability aligns with PSS goals.

Technology as Enabler:
- Leverage AI, IoT, and data analytics to make services more predictive and personalized & use digital platforms to connect smart home devices with associated services seamlessly.

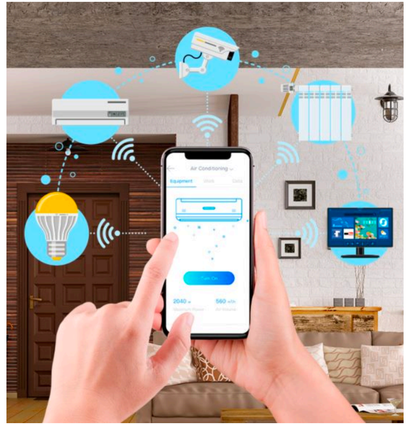
Why This Was Important for Phase Two

Understanding User Behavior & Adoption Patterns
- Researching why people adopt or resist smart home technology helped me identify key drivers (convenience, security, status) and barriers (privacy concerns, cost, complexity).
- This directly informed how I approached user needs in energy-efficient smart home solutions in Phase Two.

Recognizing the Role of Comfort & Personalization
- Many adoption decisions are based on how well technology integrates into daily life without disruption.
- This realization shaped my thinking on how smart home energy solutions should not only be sustainable but also enhance comfort seamlessly.

Identifying Opportunities for Behavioral Influence
- Phase One showed me how behavioral nudges, incentives, and sociocultural norms influence technology adoption.
- In Phase Two, I leveraged this knowledge to explore how AI-driven energy-saving systems could be designed to encourage effortless sustainable behavior.

Bridging Social, Technological, and Environmental Impact
- Understanding the sociocultural aspects of smart homes allowed me to approach sustainability not just as a technical problem but as a user-driven experience.
- This led me to explore ways smart home technology can drive sustainable habits while remaining intuitive and user-friendly.



By first exploring the sociocultural context of smart home adoption, I built a user-centric perspective that guided my transition into Smart Technologies for Energy & Comfort, ensuring my research remained impact-driven and practically applicable.

PHASE TWO:

SMART TECHNOLOGIES IN CONJUNCTION WITH ENERGY SAVING & COMFORT IN AN HOME ENVIRONMENT

For this section of my process, I began by researching and analyzing secondary sources to gain a deep understanding of the role of smart technologies in energy efficiency and comfort. Given the vast amount of information available, I focused on five key studies **(Figure 2.14)** that provided reliable data, peer-reviewed research, and industry insights into smart home energy management.

To ensure that I was relying on high-quality, trustworthy research, I developed a credibility scoring system based on five key criteria:

1. Peer Review Status– Studies published in peer-reviewed journals were rated higher than industry white papers or non-reviewed reports.
2. Research Methodology– I assessed whether the study used quantitative data, real-world case studies, statistical modeling, or comparative analysis to validate its findings.
3. Author Expertise & Institutional Backing– I prioritized research conducted by recognized experts, government agencies, or institutions specializing in energy efficiency.
4. Citation Frequency & Influence– Studies widely referenced in academic, industry, or policy discussions received higher scores.
5. Recency– More recent studies (2023–2025) were given priority, as energy efficiency and smart home technologies evolve rapidly.

Figure 2.14

Research Paper	Authors & Source	Credibility	Peer Reviewed	Citation
Energy Impacts of Smart Home Technologies	ACEEE (Jennifer King, 2018)	Government-backed research with funding from EPA, CenterPoint Energy, Eversource Energy, and Southern California Edison. Highly cited in energy efficiency literature.	Yes	King, J. (2018). Energy Impacts of Smart Home Technologies. American Council for an Energy-Efficient Economy (ACEEE), Report A1801. Retrieved from ACEEE
The Impact of Smart Home Technologies on Energy Efficiency	Journal of Energy Engineering and Thermodynamics (Ukpene, 2024)	Recent (2024) peer-reviewed publication in an energy engineering journal.Focused on real-world data from Nigerian households.	Yes	Ukpene, P. C., & Apaokueze, T. N. (2024). The Impact of Smart Home Technologies on Energy Efficiency, Cost Savings, and Environmental Benefits. Journal of Energy Engineering and Thermodynamics, 4(4), 21-32. DOI: 10.55529/jeet.44.21.32
Energy Efficiency Assessment in Smart Homes	BIO Web of Conferences (Malysheva et al., 2024)	Peer-reviewed and published in a scientific journal. Uses comparative statistical methods to assess energy efficiency.	Yes	Malysheva, Y., Ivanova, E., & Petrov, A. (2024). Energy Efficiency Assessment in Smart Homes: A Comparative Analysis. BIO Web of Conferences, 34, 1–12. DOI: 10.1051/bioconf/20243410012
Smart Buildings: Using Smart Tech to Save Energy	ACEEE (Jennifer King & Perry, 2017)	Published by ACEEE, which is a highly reputable energy research institution. Focuses on commercial smart buildings but offers insights for homes.	Yes	King, J., & Perry, C. (2017). Smart Buildings: Using Smart Technology to Save Energy in Existing Buildings. American Council for an Energy-Efficient Economy (ACEEE), Report A1701. Retrieved from ACEEE
Smart Energy Management & IoT Optimization	Various Industry Sources	Published in a Taylor & Francis journal (Cogent Engineering). Strong AI and IoT focus on home energy efficiency.	No	Karuna, G., Ediga, P., Akshatha, S., Anupama, P., Sanjana, T., Mittal, A., Rajvanshi, S., & Habelalmateen, M. I. (2024). Smart Energy Management: Real-time Prediction and Optimization for IoT-enabled Smart Homes. Cogent Engineering, 11(1), 2390674. DOI: 10.1080/23311916.2024.2390674

Breaking Down the Three Most Credible Studies

A common mistake in secondary research is including too many sources without critically analyzing them. Thats why, I chose to highlight the three most credible sources here. Credibility matters when making evidence-based claims—especially in sustainability and technology research. By referencing only the strongest studies, I could confidently justify my project's direction and design decisions. This approach eliminated weak or speculative sources, ensuring that my research held up under scrutiny.

Residential sector savings could reach 17% if all major smart technologies (HVAC, lighting, appliances, water heating) are adopted

01. AI-Driven Smart Home Energy Management (Study 1: 2024)

Findings:

- AI-based Home Energy Management Systems (HEMS) reduce energy use by 10–30% through real-time optimization.
- Machine Learning models (Gradient Boosting, Decision Trees) predict energy consumption with 95% accuracy, helping optimize power usage.
- Smart meters and IoT-enabled sensors (e.g., ACS712, ZMPT101B) track and regulate energy fluctuations at the appliance level.

How This Informed My Process:

- Confirmed that AI and IoT are critical for automating energy efficiency.
- Highlighted the need for predictive energy management rather than manual user adjustments.

02. Behavioral Impact of Smart Home Technologies (Study 2: ACEEE, 2018)

Findings:

- Smart thermostats reduce heating/cooling energy by 10–20%, optimizing HVAC use without sacrificing comfort.
- Smart appliances (dishwashers, washing machines) achieve 10–15% lower consumption, especially in energy-saving modes.
- Smart lighting reduces energy usage by up to 17% when integrated with motion sensors and dimming features.
- Barriers to adoption include high upfront costs and lack of awareness among consumers.

How This Informed My Process:

- Showed that energy savings depend not only on AI but also on user behavior and adoption incentives.
- Reinforced the need for user engagement strategies (e.g., energy reports, gamified rewards).

03. Environmental & Financial Impact of Smart Homes (Study 3: 2024)

Findings:

- Smart home technology reduces CO_2 emissions by 500–700 kg per year per household.
- Solar panels combined with smart grids significantly reduce reliance on traditional power sources.
- Smart plugs cut energy use by 25–50% by eliminating standby power consumption.
- Smart thermostats lower temperature settings by 1°C on average without users noticing, proving behavioral nudging can be effective.

How This Informed My Process:

- Reinforced the idea that smart home sustainability goes beyond energy savings—it also impacts carbon reduction.
- Highlighted the potential for integrating renewable energy into smart home ecosystems.

Smart Home Product Categories in Energy Saving

This section categorizes smart home energy management components **(Figure 2.15)** that contribute to energy efficiency, automation, and user comfort. Each component plays a distinct role in optimizing energy use, reducing costs, and improving home sustainability.

Components	Overview	Features	Notable Products
Energy Monitoring Systems	These systems provide real-time insights into household energy consumption, helping users identify high-usage devices and develop strategies to reduce energy costs.	• Real-time energy usage tracking. • Appliance-level monitoring. • Historical data analysis. • Alerts for unusual consumption patterns.	• Sense Energy Monitor: Provides detailed energy usage reports and appliance detection. • Emporia Vue Energy Monitor: Affordable solution with circuit-level monitoring. • Neurio Home Energy Monitor: Offers real-time monitoring with solar integration.
Smart Home Energy Management Systems (SHEMS)	SHEMS integrate various smart devices into a cohesive system to optimize overall home energy consumption.	• Centralized control of connected devices. • Automated energy-saving routines. • Integration with renewable energy sources. • Compatibility with a wide range of smart devices.	• Samsung SmartThings Energy: First mass-market smart home energy management system to earn ENERGY STAR certification. • energystar.gov • Schneider Electric Wiser Energy System: Monitors energy usage and provides actionable insights. • Vivint Smart Home: Offers comprehensive home automation with energy management features.
Renewable Energy Integration	Products in this category focus on integrating renewable energy sources, such as solar panels and home batteries, into the smart home ecosystem.	• Solar energy generation and monitoring. • Home battery storage systems. • Energy usage optimization based on renewable availability. • Grid interaction capabilities.	• Tesla Powerwall: Home battery system that stores energy from solar panels for use when needed. • Moixa Smart Battery: Pairs with residential solar panels to optimize energy use.

Figure 2.15

Components	Overview	Features	Notable Products
Smart Thermostats	Smart thermostats enable users to remotely control home heating and cooling systems, learn user preferences, and adjust settings to maximize energy efficiency.	• Remote temperature control via smartphone apps. • Learning algorithms that adapt to user behavior. • Integration with other smart home devices. • Energy usage reports and insights.	• Nest Learning Thermostat: Offers auto-scheduling and energy usage tracking. • ecobee SmartThermostat: Includes room sensors for enhanced temperature control. • Honeywell Home T9: Features smart room sensors and customizable scheduling.
Smart Lighting	Smart lighting systems provide adjustable lighting solutions that can be controlled remotely, scheduled, and automated to reduce energy consumption.	• Remote control and scheduling via apps. • Dimmable and color-changing options. • Integration with voice assistants. • Energy-efficient LED technology.	• Philips Hue: Offers a wide range of bulbs and fixtures with extensive customization. • LIFX Smart Bulbs: Provides vibrant colors and high brightness levels. • TP-Link Kasa Smart Wi-Fi Light Bulb: Affordable smart lighting with easy setup.
Smart Power Strips and Plugs	These devices allow users to monitor and control the power usage of connected appliances, helping to eliminate standby power consumption.	• Remote on/off control via smartphone apps. • Energy monitoring and reporting. • Scheduling and automation capabilities. • Overload protection.	• Belkin WeMo Insight Smart Plug: Monitors energy usage and provides real-time reports. • TP-Link Kasa Smart Wi-Fi Power Strip: Features multiple outlets with individual control. • Amazon Smart Plug: Seamless integration with Alexa for voice control.
Smart Appliances	Smart appliances, such as refrigerators, washing machines, and ovens, offer advanced features like energy monitoring, remote control, and optimized operation to enhance efficiency.	• Remote monitoring and control. • Energy consumption tracking. • Automated maintenance alerts. • Integration with smart home ecosystems.	• Samsung SmartThings Appliances: Comprehensive integration with the SmartThings platform. • LG SmartThinQ Appliances: Wide range of smart appliances with AI capabilities. • GE Profile Smart Appliances: Features like remote monitoring and voice control.

Figure 2.15

By categorizing these smart home components, I was able to map out the key areas where AI, automation, and sustainability intersect. These technologies not only reduce energy consumption but also enhance user experience through personalization, automation, and real-time insights.

Balancing Energy Efficiency & Comfort Through AI-Driven Smart Home Technologies

Going through my research and all of my findings and readings from my studies, I discovered that energy efficiency and comfort are not opposing forces but interconnected elements of a well-designed smart home. The key lies in AI-driven automation, seamless integration, and user behavior adaptation.

01.AI-Driven Optimization: Enhancing Both Efficiency & Comfort

Energy Efficiency Impact: Machine learning models optimize energy consumption in real time, outperforming manual user interventions.

Comfort Impact: AI-driven systems learn from user habits, adjusting temperature, lighting, and air quality for an effortless experience.

Example: Smart thermostats don't just save energy; they maintain optimal comfort levels without user input.

Next Step: This reinforced my focus on AI as the bridge between energy conservation and personalized comfort.

02. Reducing Cognitive Load Through Automation

Energy Efficiency Impact: Smart Home Energy Management Systems (HEMS) automate energy optimization, ensuring appliances operate only when needed.

Comfort Impact: Comfort isn't just physical—it's also mental ease. Automation reduces user effort, eliminating the need for constant adjustments.

Example: AI-driven systems anticipate needs—turning lights on gradually in the morning, adjusting AC based on real-time occupancy.

Next Step: I realized that for smart homes to be widely adopted, they must be intuitive—creating a frictionless, self-adaptive environment.

03. Smart Appliances & Lighting: Immediate Savings & Well-Being

Energy Efficiency Impact: Smart appliances and motion-activated lighting offer quick financial and environmental benefits, reducing consumption by 10-30%.

Comfort Impact: Lighting, sound, and ambient conditions impact emotional well-being—smart systems adjust these elements to enhance relaxation and productivity.

Example: Smart lighting that follows circadian rhythms supports better sleep and focus, blending energy conservation with human-centered design.

Next Step: This inspired me to design AI-powered smart home solutions that optimize both efficiency and emotional comfort.

04. Behavior-Driven Customization: Aligning Tech with User Preferences

Energy Efficiency Impact: AI-driven behavioral learning ensures energy-saving measures are intuitive and not disruptive.

Comfort Impact: Users are more likely to adopt smart technology if it aligns with their lifestyles and preferences rather than enforcing rigid efficiency rules.

Example: A thermostat that forces a cold setting to save energy may be overridden, but one that gradually adapts to user habits is more effective.

Next Step: This insight influenced my decision to explore behavior-driven AI, ensuring energy-saving features remain user-friendly and adaptable.

05. Smart Grid Integration: The Next Step for Sustainable Smart Homes

Energy Efficiency Impact: Connecting smart homes to decentralized energy grids enhances efficiency by optimizing power distribution and integrating renewables.

Comfort Impact: AI can ensure a seamless transition between grid and renewable energy sources, ensuring uninterrupted comfort while reducing costs.

Example: Smart systems can prioritize solar energy use when available, automatically adjusting settings for optimal performance.

Next Step: This led me to explore how AI and smart grids can work together to create a more resilient, self-sustaining smart home ecosystem.

How This Redefined My Research Direction

- **Shifted My Focus from Just Energy Savings to a User-Centric Approach** – I realized that comfort and efficiency must coexist to drive smart home adoption.
- **Emphasized Seamless Automation** – AI-driven systems reduce user effort, making automation intuitive, adaptive, and non-intrusive.
- **Integrated the Psychological Aspect of Comfort** – Comfort is not just physical (temperature, air quality) but also emotional (lighting, personalization, stress reduction).
- **Framed AI as the Key to Merging Sustainability & Comfort** – Instead of treating energy savings and comfort as separate goals, I explored how AI-driven smart homes can merge them into a unified experience.

This research shaped my perspective that smart homes should not force users to compromise between comfort and sustainability. Instead, AI-driven, behavior-adaptive systems can create an environment that is both energy-efficient and effortlessly comfortable. This became the foundation for my Phase Two research, where I explored how AI, automation, and behavior-driven adaptation can make smart homes sustainable, intuitive, and human-centered.

Environmental Impact

What are Carbon Emissions & how to measure it?

Carbon emissions refer to the release of carbon dioxide (CO_2) and other greenhouse gases (GHGs) into the atmosphere, primarily from human activities such as burning fossil fuels (coal, oil, gas), industrial processes, and deforestation. These emissions trap heat in the Earth's atmosphere, contributing to global warming and climate change.

Sources of Carbon Emissions in Homes:

In a smart home environment, carbon emissions mainly come from:

- Electricity use – Powering lights, appliances, heating, and cooling systems.
- Heating & Cooling – Gas or electric furnaces, air conditioning units.
- Water Heating – Gas or electric water heaters.
- Transportation – Charging electric vehicles or fuel-based heating systems.

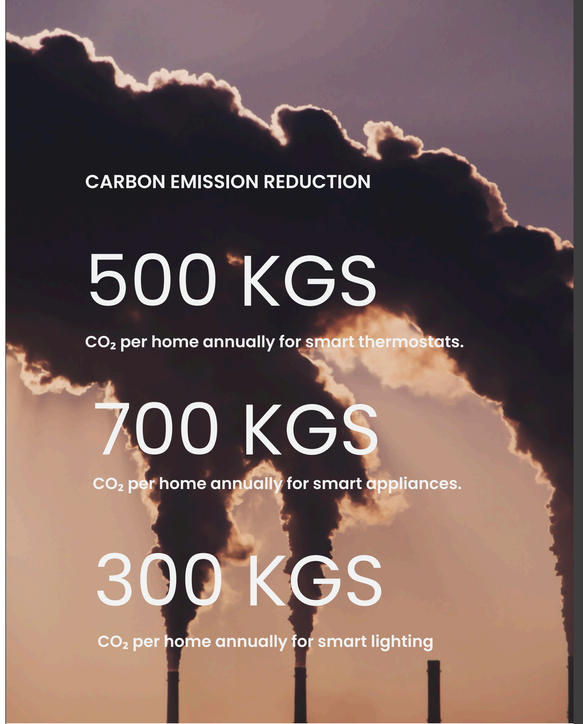
To measure Carbon Emission Reduction in smart home technologies, follow these steps:

- Calculate Baseline Emissions – Measure energy consumption before implementing smart tech (e.g., kWh used by appliances).
- Measure Post-Implementation Emissions – Record energy consumption after smart home upgrades (e.g., using smart thermostats, AI automation).

Use the Formula:

Carbon Emission Reduction=Baseline Emissions-Post-Implementation Emissions

  - Example: If smart home automation reduces electricity usage from 4,000 kWh to 3,500 kWh, and the emission factor is 0.92 kg CO_2 per kWh, the reduction is 460 kg CO_2 per year.
- Apply Standard Protocols – Use the GHG Protocol or ISO 14064 to ensure accurate measurement.
- Consider User Behavior – Seamless integration of smart tech improves energy efficiency without disrupting user comfort.



"ENERGY EFFICIENCY ALONE ISN'T ENOUGH—SMART HOMES SHOULD FEEL INTUITIVE, SEAMLESS, AND NON-INTRUSIVE. ARTIFICIAL INTELLIGENCE AND IOT SENSORS CREATE A SEAMLESS EXPERIENCE BY LEARNING USER HABITS, PREDICTING OPTIMAL ENERGY USAGE, AND AUTOMATICALLY ADJUSTING SMART HOME SYSTEMS." (P. 8)

Malysheva, Y., Ivanova, E., & Petrov, A. (2024).

Energy Efficiency Assessment in Smart Homes: A Comparative Analysis. BIO Web of Conferences, 34, 1–12. DOI: 10.1051/bioconf/20243410012

Key Quotes & Insights: (With Contradictions & Agreements)

As I explored energy efficiency in smart homes, I noticed that different studies presented conflicting perspectives on key issues such as automation, user engagement, trust, and privacy. Rather than treating these contradictions as obstacles, I saw them as opportunities to dig deeper into the complexities of smart home adoption.

ENERGY EFFICIENCY VS. CONSUMER BEHAVIOR

Energy Impacts of Smart Home Technologies (ACEEE, 2018):
"Smart thermostats can reduce heating and cooling energy use by 8-20%, but effectiveness depends heavily on how users interact with the system. Many users override settings due to discomfort or misunderstanding." (p. 18)

Energy Efficiency Assessment in Smart Homes (2024):
"AI-driven smart home automation eliminates the need for manual control, providing predictable and optimized energy savings of up to 30% in homes without user interference." (p. 10)

Contradiction → Study 1 states that user engagement is necessary for energy savings, while Study 2 claims that automation alone can drive efficiency without user intervention.

ADOPTION BARRIERS VS. SEAMLESS INTEGRATION

Smart Buildings Report (2017):
"For smart home systems to be widely adopted, they must be invisible yet effective—users should not have to constantly interact with the system for it to work efficiently." (p. 14)

Energy Impacts of Smart Home Technologies (2018):
"Adoption of smart home technologies remains low due to cost, lack of consumer trust, and privacy concerns. Only 27% of surveyed users fully utilize their smart thermostats." (p. 22)

Agreement → Both studies agree that usability is key, but one argues for automation over manual control, while the other highlights trust barriers to adoption.

AI VS. PRIVACY & SECURITY CONCERNS

Energy Efficiency Assessment in Smart Homes (2024):
"Artificial intelligence and IoT sensors create a seamless experience by learning user habits, predicting optimal energy usage, and automatically adjusting smart home systems." (p. 8)

Energy Impacts of Smart Home Technologies (2018):
"While AI-driven automation can reduce energy waste, many users are concerned about data privacy, with 42% hesitant to allow AI control over their home environment." (p. 24)

Contradiction → Study 2 praises AI for its ability to optimize without manual control, but Study 1 warns that trust issues prevent users from relying on AI-driven decisions.

How This Informed My Next Steps

Refined My Approach to Automation – Instead of treating AI-driven efficiency and user control as separate ideas, I looked at how they could coexist through adaptive, behavior-driven AI.

Addressed Adoption Barriers – By acknowledging that privacy and trust issues impact adoption, I began considering user education, transparent data policies, and customizable automation settings.

Framed AI as a Trust-Building Tool – Instead of seeing AI as just a means for automation, I explored how it could be used to enhance user confidence by learning preferences without violating privacy.

Integrated Consumer Behavior Insights – I shifted from a purely technology-focused perspective to a human-centered approach, ensuring that AI aligns with real-world user concerns and habits.

By analyzing these contradictions and agreements, I was able to develop a more balanced perspective—one that doesn't just focus on the technical potential of smart homes but also considers real-world adoption challenges and user needs.

"AI-DRIVEN SMART HOME TECHNOLOGIES NOT ONLY OPTIMIZE ENERGY CONSUMPTION BUT ALSO ENHANCE USER COMFORT BY LEARNING AND ADAPTING TO INDIVIDUAL HABITS, CREATING A SEAMLESS AND EFFICIENT LIVING ENVIRONMENT."

IEEE. 2020

Core Research Areas

This research **(Figure 2.16)** confirmed that the best smart home experiences are invisible yet effective—optimizing energy use while maintaining user comfort and trust. Moving forward, I explored how AI-driven smart homes can create a self-sustaining, adaptive environment that blends energy efficiency, personalization, and effortless usability.

Challenges

High Initial Cost: Many homeowners hesitate due to high upfront investment.

Grid Compatibility: Need for better integration with existing energy infrastructure.

Awareness Gap: Many consumers remain unaware of smart home energy savings.

Cybersecurity Risks: Concerns over IoT security vulnerabilities impact adoption rates

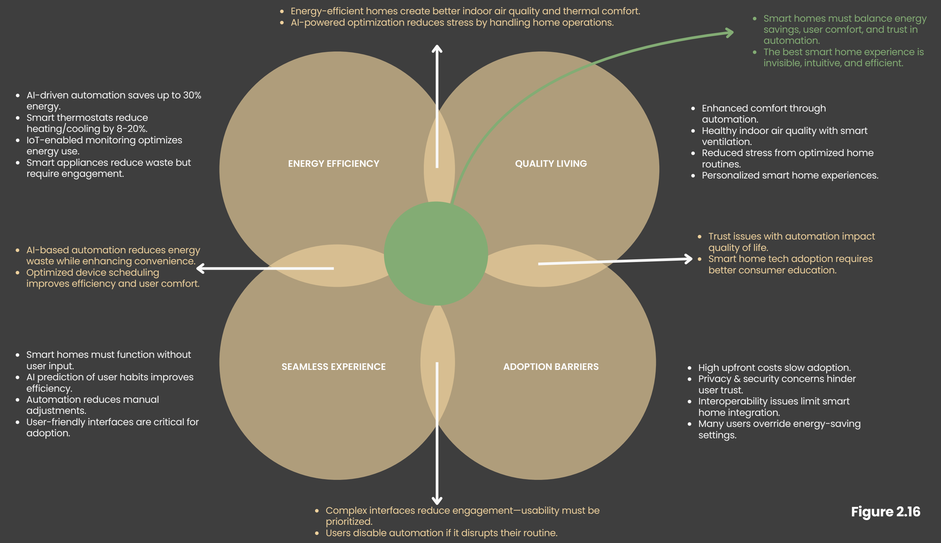


Figure 2.16

In Conclusion

This journey has reinforced that the success of smart homes is not just about energy efficiency, automation, or advanced technology—it's about how well these elements integrate into people's lives without friction. The best smart home is one that users don't have to think about, yet always enhances their daily experience.
Moving forward, my project will continue to explore how AI, automation, and behavioral adaptation can create a truly sustainable, intuitive, and human-centered smart home experience.

Designing a Holistic Smart Home Framework

- Instead of viewing sustainability, automation, and comfort as separate goals, I now see them as interconnected elements of a smart home experience.
- Moving forward, my project will focus on creating AI-driven smart home solutions that seamlessly integrate energy efficiency with intuitive user experiences.

Prioritizing Adaptive AI for Energy & Behavior Optimization

- Instead of rigid automation, AI should adapt to user preferences over time, learning behaviors rather than imposing predefined settings.
- This allows for a user-centric approach that builds trust, enhances comfort, and promotes energy-saving behaviors.

Developing a Scalable & Inclusive Smart Home Model

- My research showed that adoption challenges vary across demographics—financial incentives, trust-building strategies, and usability improvements are key to making smart home technology more accessible.
- Moving forward, I will explore how AI-driven smart homes can be personalized for different consumer needs while maintaining sustainability.

MY TARGET AUDIENCE

At the start of my project, my goal was to understand energy efficiency adoption across diverse demographics, including low-income households, family households, renters, and young professionals. I explored how different socio-economic groups interact with smart home technologies and what barriers they face in adopting energy-efficient solutions.
However, as I progressed through primary and secondary research, I realized that my initial audience scope was too broad. This led me to refine my target users to Dual-Income Eco-conscious Homeowners and Young Budget-friendly Renters—a shift that emerged organically as I identified key behavioral patterns and adoption drivers.

MARKET RESEARCH

The number of renter households in the U.S. grew three times faster than the number of homeowner households in 2Q 2024, driven by the increasing disparity between rent payments and the rising cost of mortgages.

Maister, P. (2024, August 6)

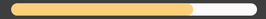
"Protecting the environment is the societal challenge where respondents feel businesses have the greatest opportunity and necessary influence to drive change. And Gen Zs and millennials are pushing business to do so, through their career decisions and their consumer behaviors."

Deloitte. (2024). 2024 Gen Z and Millennial Survey: Living and working with purpose in a transforming world.

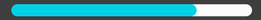
57% of U.S. consumers are projected to adopt smart home technology by 2025

U.S. households with smart home devices own an average of 8 devices

74% of broadband households are concerned about their personal data security



77% of smart home users are under 55 years of age



Howarth, J. (2022, November 14)

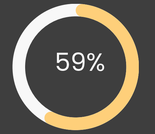
GENZS

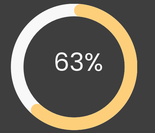
Percentage reporting feeling anxious or worried about climate change

Percentage willing to pay more to purchase environmentally sustainable products or services

Percentage who have stopped or lessened a relationship with a business due to unsustainable practices in the supply chain

MILLENNIALS





FAMILY HOUSEHOLDS

of families have two full-time working parents.

of working parents report difficulty balancing work and family.

Percentage of Children Living with 2 Parents Reaches Highest Level in Decades

Behaviour, Attitudes & Challenges

- Busy families struggle to balance time-consuming household chores with their personal and professional commitments, leading to stress and reduced quality time.
- Managing overlapping schedules and tasks for family members is chaotic, often resulting in missed commitments and increased tension.
- Families face difficulty balancing energy efficiency, sustainability goals, and household comfort due to a lack of real-time data and automation.
- Ensuring safety at home is a priority for families, but managing multiple security devices and monitoring systems can feel overwhelming and unreliable.
- Families find it challenging to plan meals and manage groceries efficiently, leading to food waste, stress, and unhealthy eating habits.

My Initial Target Audience: Who I Started With

At first, I looked at a wide range of potential users, focusing on those most affected by energy efficiency challenges:

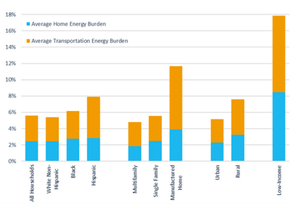
Low-Income Households
- **Key Insight**: Experience energy burdens 3.5 times higher than the average, often struggling with affordability.
- **Challenge Identified**: Cost remains a major adoption barrier—most smart home solutions are not designed for low-income households, and financial incentives are limited.

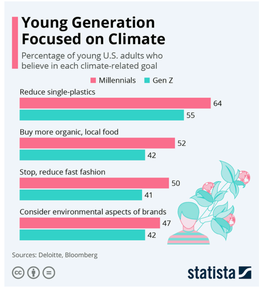
Renters
- **Key Insight:** Face property restrictions that limit their ability to install smart home devices.
- **Challenge Identified:** Many smart solutions require permanent installation, which does not align with renter flexibility needs.

Young Professionals (Gen Z & Millennials)
- **Key Insight:** Gen Z & Millennials express high environmental concern, yet only 37% actively reduce their energy use.
- **Challenge Identified:** The gap between environmental awareness and action—young professionals are interested in sustainability but lack accessible, budget-friendly smart home options.

Family Households
- **Key Insight**: Families manage higher energy usage but also have more financial flexibility to invest in long-term energy solutions.
- **Challenge Identified:** They prioritize comfort and convenience, meaning energy-efficient solutions must integrate seamlessly into family routines without disruptions.

U.S. Department of Energy. (n.d.).
World Economic Forum. (2022).





Through primary research (interviews, surveys, case studies), I started seeing patterns in smart home adoption—who was most interested, who was actively making changes, and who faced the most practical barriers. This led to a targeted shift in my audience.

Dual-Income Eco-Conscious Homeowners

Why They Became a Focus:
- Have financial flexibility to invest in energy-saving smart home solutions.
- Motivated by sustainability—they actively look for ways to reduce their carbon footprint while maintaining a high-quality living environment.
- Prefer seamless, automated solutions—they want smart homes that integrate effortlessly into daily life without requiring constant manual adjustments.

What This Shift Meant for My Research:
- Focused more on high-value smart home integrations (e.g., AI-driven automation, smart thermostats, renewable energy integration).
- Explored how AI can enhance both energy efficiency and user comfort in a way that fits a dual-income, time-constrained lifestyle.

Young Budget-Friendly Renters

Why They Became a Focus:
- Want energy-efficient solutions but cost and property restrictions limit adoption.
- Prioritize affordability and portability—they can't install permanent smart systems, so they need plug-and-play, modular solutions.
- Growing interest in sustainability, but they seek low-commitment, low-cost entry points into smart home technology.

What This Shift Meant for My Research:
- Shifted focus toward modular, renter-friendly smart devices (e.g., smart plugs, portable energy monitors, subscription-based smart home services).
- Considered how behavioral nudges and gamification could increase adoption—making sustainability more engaging for renters.

Kim, S., Lee, J., & Park, H. (2022)
International Energy Agency. (2023)
Statista. (2023)

Why This Shift Strengthened My Project

By refining my target audience to Dual-Income Eco-Conscious Homeowners & Young Budget-Friendly Renters, I was able to:

- **Align my research with real adoption potential—** focusing on users who actively seek smart energy solutions rather than those with financial or structural limitations.
- **Balance long-term investment (homeowners) with low-commitment, flexible options (renters)—** ensuring my project considered both scalability and accessibility.
- **Ensure my final solutions fit actual user needs—** shifting toward AI-driven automation for efficiency and modular, renter-friendly smart home products.

This evolution in my audience understanding allowed me to move forward with a sharper, more impactful approach, making my project more actionable, realistic, and aligned with real-world consumer behavior.

03. PRIMARY RESEARCH

To gain firsthand insights into user behaviors, motivations, and barriers related to my project topic “Smart Technologies in Conjunction with Energy Saving & Comfort in an Home Environment”, I conducted mixed methods primary research through user interviews (qualitative) and behavior journals (quantitative). This approach helped me bridge the gap between how people interact with smart technology in their daily lives and what factors drive or hinder adoption.

Target Participants: Who I Engaged With

Demographic: Homeowners & Renters in the USA
Tech-savvy and eco-conscious – Already interested in sustainability or smart technology.

Why This Group?

- Homeowners and renters were accessible for my research during my primary research timeline.
- Renters sought portable, budget-friendly smart solutions.
- Tech-savvy users provided insights on usability and integration challenges.

RESEARCH QUESTIONS

User Interviews Plan

- **Format**: Semi-formal, conducted over Zoom
- **Duration**: ~40 minutes per interview
- **Objective**: Understand how users engage with smart home technologies, their expectations, and key adoption challenges.

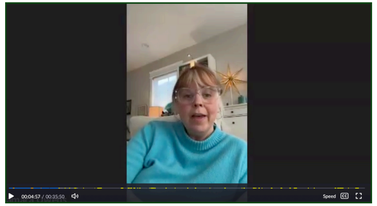
My Approach:

- Used open-ended questions to encourage detailed responses and real-life anecdotes.
- Maintained a flexible structure to allow for follow-up questions based on participant feedback.
- Focused on three key themes:

1. Experience with Smart Home Technology – Whether they own or use smart devices and how they integrate them into daily life.
2. Resource Management Habits – How they manage energy, water, and waste and their level of awareness of sustainability efforts.
3. Pain Points & Barriers – Challenges in adopting smart systems, including cost, usability, and privacy concerns.

How This Informed My Process:

- Helped identify which features users value most in smart homes (e.g., automation, ease of use, cost savings).
- Highlighted key adoption barriers like lack of trust, upfront costs, and integration challenges.
- Provided insights into how AI-driven automation could make sustainability effortless for users



User Interviews Questions

User Interview Questions for a Family-Oriented Smart Home User in Their Late 40s/Early 50s

Introduction

- Tell me about your household (number of members, ages, routines).
- What motivated you to adopt a smart home system (convenience, savings, security)?

Smart Home Usage

- What smart devices do you use most?
- Which devices are most helpful? Any that are difficult or unused?
- How often do you interact with your smart home system?

Sustainability & Energy Efficiency

- Do you track energy usage or use eco-friendly settings?
- Have you noticed changes in energy/water bills since using smart devices?
- Do your smart devices help with sustainability efforts at home?

Family Interaction & Smart Home Dynamics

- How does your family use the smart home system?
- Are there any conflicts or challenges in usage?
- Has the system improved household routines or communication?

Automation & AI

- How do you feel about automation (e.g., auto-adjusting thermostat, scheduled lighting)?
- Do you prefer manual control or automated settings?
- Would you trust AI to manage more of your home's energy use? Why or why not?

Future Expectations

- What new feature would you add to your smart home system?
- What improvements would make you invest further in smart home tech?
- How important is privacy and security when using smart home devices?

User Interview Questions for University Students who are Young Renters

Introduction

- Tell me about your living situation (dorm, apartment, roommates).
- Have you used smart home devices before? If so, which ones?

Daily Habits & Lifestyle

- How do you manage everyday tasks (lighting, heating, appliances)?
- Are there any chores that feel repetitive or time-consuming?
- How much do you think about energy usage (turning off lights, unplugging devices)?

Technology & Automation

- Do you use smart devices or apps (smart plugs, voice assistants, energy trackers)?
- Do you find tech convenient, or do you prefer manual control?
- Have you considered smart home systems for energy savings? Why or why not?

Sustainability Awareness

- What does sustainability mean to you?
- Do you actively try to reduce energy/water usage?
- Would you use a system that tracks and helps reduce your resource consumption?

Expectations from Smart Home Systems

- What would you want a smart system to do for you (reminders, automation, tracking)?
- Would you trust a system to automate things like temperature and lighting?
- Would lower utility bills motivate you to use smart home tech?

Barriers & Concerns

- What are the biggest challenges to adopting smart home tech (cost, complexity, privacy)?
- Would privacy concerns affect your willingness to use smart devices?

Future Interest

- What features would a smart home system for students need?
- Would you invest in smart home devices after graduation? Why or why not?
- Would you be interested in a gamified sustainability system (earning points for energy savings)?

Behaviour Journal Plan

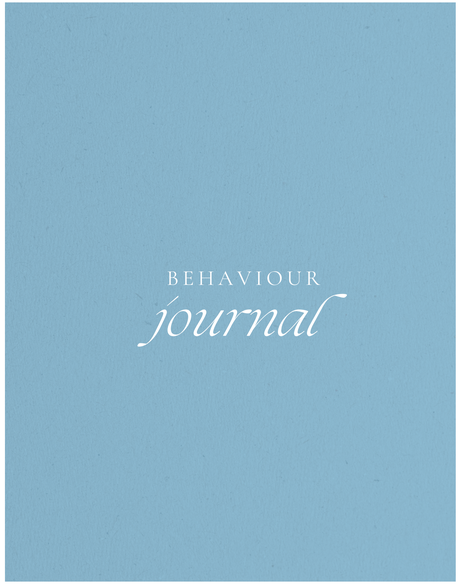
- **Format**: Informal, completed via online PDFs
- **Duration**: 7 days
- **Objective**: Track real-life interactions with household resources to uncover unconscious behaviors that impact energy use.

My Approach:
- Designed the journals to be simple and informal to encourage participation.

-Included daily prompts to log interactions with:
- Lighting (turning off/on, brightness adjustments)
- Heating/Cooling (thermostat adjustments, window usage)
- Water Use (long showers, dishwashing habits)
- Appliances (standby mode, unnecessary power use)

-Encouraged participants to note:
- Why they performed certain actions (habit, necessity, convenience).
- What triggered those behaviors (comfort, energy savings, routine).
- Whether they were aware of their resource consumption before tracking it.

How This Informed My Process:
- Revealed gaps in user awareness—many participants underestimated their energy and water usage.
- Showed that small behavioral nudges (like energy usage feedback) could encourage better habits.
- Highlighted that smart automation could help users reduce energy waste without effort.



THIS BOOK BELONGS TO:

_____

_____

To track daily habits and interactions with your home systems, focusing on small, unconscious actions that impact energy use, resource consumption, and sustainability.

Duration:
1 week (7 days).

How to Use This Journal:

Spend just 5 minutes daily to complete the journal.
Keep it simple–use checkboxes and short notes.
Track only what you remember–no need to monitor every detail.

Instructions for Submission:

Fill out the journal daily for 7 days.
Keep it honest and easy–this is about tracking trends, not perfection.

Behaviour Journal

TIME: _____ DATE ____ /____ /____

MOOD

S M T W T F S

ANGRY TIRED SAD GREAT FUN

Section 1: Energy Use

Lighting: Did you leave any lights on when not needed?

- ◯ NO, I TURNED THEM OFF.
- ◯ YES, BY MISTAKE.
- ◯ NOT SURE.

Devices and Appliances: Did you unplug or switch off unused devices (e.g., chargers, TVs, laptops)?

- ◯ YES
- ◯ NO

NOTE: _____

Thermostat or Heating/Cooling: Did you adjust the temperature manually?

- ◯ YES, TO SAVE ENERGY.
- ◯ NO, IT STAYED AS IS.

NOTE: _____

Section 2: Water Use

Taps and Showers: Did you leave water running unnecessarily (e.g., while brushing, washing)?

- ◯ NO, I WAS MINDFUL.
- ◯ YES, BY MISTAKE.

Section 3: Waste Reduction

Waste Disposal: Did you sort recyclables and reduce waste today?

- ◯ YES
- ◯ NO, EVERYTHING WENT INTO ONE BIN.

Section 4: Smart Home Technology (If Applicable)

Automation: Did a smart device help automate any action (e.g., turning off lights, adjusting thermostat)?

- ◯ YES, IT WORKED AS INTENDED.
- ◯ NO, I HAD TO DO IT MANUALLY.

Overriding Automation: Did you manually override a smart system?

- ◯ YES, BECAUSE IT WASN'T HELPFUL.
- ◯ NO, I RELIED ON THE AUTOMATION.

Were there any moments today where you thought about how your actions at home might be impacting your monthly expenses (e.g., electricity, water, heating)?

- ◯ IF YES, WHAT TRIGGERED THIS THOUGHT?
- ◯ IF NO, WHY DO YOU THINK IT DIDN'T COME TO MIND?

NOTE: _____

Section 5: Reflections

Did you notice any actions that felt unsustainable?

_____

_____

_____

_____

_____

_____

Conducting primary research was both challenging and rewarding. Balancing user interviews and behavior journals was particularly interesting, as each served a distinct purpose. The behavior journals required consistent follow-ups to ensure participants logged their daily habits, while the user interviews flowed smoothly, with participants being engaged and insightful.

The insights I gathered were far more impactful than I anticipated, shaping my secondary research in unexpected ways. To stay organized, I created a January 2025 calendar **(figure 3.1)**, mapping out daily tasks from the 12th (the day I committed to smart homes as my focus) up to the midpoint presentation. This structured approach kept me on track and ensured I covered every aspect of my research effectively.

Figure 3.1

JANUARY 2025

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12 TOPIC CHANGE	13 Revised Opportunity Statement	14	15 Secondary Research	16 Secondary Research  User Interviews	 Secondary Research  Distributed Behaviour Journals	18   Secondary Research
19 Secondary Research	20  ERAF MApping Secondary Research	21 Presentation Prep	22 Research Presentation Due	23 Secondary Research	24 Affinity Mapping Collection of completed behaviour journals	25 Revised Interview Questions Scheduling user interviews
26	27 Second round of user interviews	28 Second round of user interviews	29 Second round of user interviews	30 Second round of user interviews	31 Triangulation of Insights Affinity Mapping	1

BEHAVIOUR JOURNAL PROCESS & INSIGHTS

Meet the participants

Paul, 61
Homeowner, Tallahassee

Somya, 26
Renter, Savannah

Tamara, 51
Homeowner, Savannah

Alex, 22
Renter, New York

Cameron, 31
Renter, Tampa Bay

INSIGHTS

Majority are mindful of turning off lights 4/5 users

Gamification or incentives could help reinforce better habits. 4/5 users

Automation helped reduce human errors 3/5 users

Those who used automation found it helpful in reducing energy waste. 3/5 users

Users had to override automation manually. 5/5 users

The behavior journal was a key part of my primary research, designed to track unconscious habits related to energy, water, and waste management. This method allowed me to observe real-life patterns that users might not even be aware of, helping me uncover gaps between intention and action in sustainability practices.

Energy Use & Lighting Behavior

- Majority are mindful of turning off lights – Most participants consistently turned off lights when leaving a room. However, occasional lapses (e.g., forgetting by mistake) were common across all participants.
- Automation helped reduce human errors – Participants with smart lighting systems reported fewer instances of forgetting to turn off lights.

Water Consumption Habits

- Mindful water usage, but lapses occur – Most participants reported being conscious of water consumption, but occasional overuse (e.g., leaving taps running) was still noted.
- Uncertainty about water waste – Some participants marked "Not sure" when asked if they wasted water, suggesting a lack of awareness regarding minor inefficiencies in their daily routines.

Device & Appliance Usage

- Inconsistent unplugging of devices – Participants were split between those who unplugged unused devices and those who did not. Some noted forgetting to unplug chargers or leaving appliances on standby.
- Energy-conscious users adjusted thermostats manually – Homeowners (Beth and Diana) were more proactive in adjusting their thermostats manually for energy savings, whereas renters were less likely to make adjustments.

Waste Sorting & Reduction

- Recycling habits vary significantly – Some participants consistently sorted recyclables, while others admitted throwing everything into one bin. Renters were more likely to skip recycling compared to homeowners.
- Behavior is not always intentional – Some participants acknowledged that they forgot or were in a hurry, leading them to dispose of everything in a single bin.

Smart Home Automation's Role

- Mixed effectiveness of smart home devices
- Those who used automation (e.g., smart thermostats, lighting) found it helpful in reducing energy waste.
- Some users had to override automation manually, either because it wasn't functioning as needed or didn't align with their preferences (e.g., overriding thermostat settings).
- Others did not have automation systems in place and had to manage energy use manually.

Reflections on Sustainability

- Common unsustainable actions identified
- Forgetting to turn off lights.
- Leaving chargers plugged in.
- Wasting water (e.g., longer showers, running taps).
- Throwing recyclables into general waste.
- Expense Awareness Varies
- Some participants actively thought about how their actions impacted monthly electricity and water bills, particularly homeowners.
- Renters, on the other hand, were less likely to consciously track how daily energy habits impacted their utility costs.

Key Insights & Takeaways

- **Mindful habits exist, but lapses are common** – Most participants turned off lights & monitored water use, but occasional forgetfulness was a trend.
- **Automation reduces human error** – Smart lighting & thermostats helped users save energy without effort, but some found automation inconvenient and manually overrode it.
- **Gaps in water & energy awareness** – Some participants weren't sure if they wasted water, indicating low visibility of small inefficiencies.
- **Recycling habits vary** – Homeowners were more consistent, while renters were less likely to sort waste, often due to convenience.
- **Cost awareness depends on homeownership** – Homeowners actively tracked energy expenses, whereas renters were less engaged with utility costs.

This research method was insightful in identifying unconscious inefficiencies, which later influenced my exploration of behavioral nudges, gamification, and AI-driven automation in smart homes.

USER INTERVIEW PROCESS & INSIGHTS

Meet the participants

Anushka, 26
Renter,
Boston

Justin, 52
Homeowner,
Savannah

Cameron, 31
Renter,
Tampa Bay

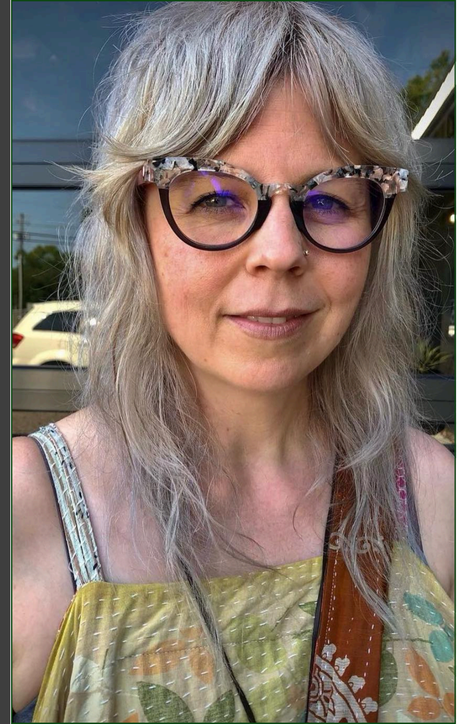
Delaney, 23
Renter,
Savannah

Santiago, 29
Homeowner,
New York

Terri, 69
Homeowner,
Tallahassee

Tamara, 51
Homeowner,
Savannah

After conducting seven in-depth interviews with both homeowners and renters, I discovered several overlapping pain points and opportunities. Before diving into these insights, the next section will present the transcribed key takeaways from each interviewee.



Tamara, 51
Homeowner, Savannah

Household: Lives with her husband and two teenage sons.

Smart Tech Used: Smart thermostats, smart lights, security system, solar panels, smart locks.

Motivation for Adopting Smart Tech	Daily Interaction with Smart Tech	Energy Savings & Efficiency	Challenges & Frustrations
"My husband works in IT, so he loves automation. We also saw it as an opportunity to save energy and make our home more efficient."	"Our heating and cooling is fully automated. We use voice commands for lights and check security cameras daily."	"The thermostat interacts with the power company and automatically enters eco-mode when the grid is stressed, lowering our electricity use. Solar panels have also cut our bills significantly."	"Sometimes, smart home tech is just inconvenient. I could flip a switch in one second, but instead, I have to stand there saying 'turn off the living room light' three times before it listens."

"My kids don't love smart home automation. They sometimes get frustrated when lights shut off automatically if they've been quiet in a room for too long. They also resent how much I recycle because our city only picks up recycling every few weeks, so it piles up."

Anushka, 26
Renter, Boston

Background & Home Setup
- Lives in a small apartment in Boston with one roommate.
- Uses Amazon Echo, Philips Hue smart bulbs, and a Nest Mini.
- Cannot install a smart thermostat or other infrastructure-heavy tech due to rental restrictions.

Experience with Smart Home Tech

"I love how my smart lights and speaker integrate into my routine. But beyond that, I don't have much control over my energy usage."
- Uses smart devices for convenience, not for energy tracking.
- Frustrated by lack of renter-friendly energy-saving solutions.
- Would love a plug-and-play smart thermostat that works without installation.

Thoughts on AI & Automation

"AI is great, but I don't trust it to make decisions for me. I'd rather have suggestions than full automation."
- Prefers manual control over automation.
- Uses smart home assistants for convenience (music, timers, lights), not for energy management.

What Would Improve Her Experience?
- Renter-friendly energy-saving solutions (portable or app-based control).
- Clear, real-time insights instead of hidden automation.
- Financial incentives tied to energy savings.

Justin, 52
Homeowner, Savannah

Background & Home Setup
- Owns a large house with his wife and teenage son.
- Uses Nest Thermostat, Ring security system, Amazon Alexa, and smart LED lights.
- Tech-savvy but still overrides automation often.

Experience with Smart Home Tech

"I love the idea of automation, but I still find myself adjusting things manually. AI doesn't always get it right."
- Frequently overrides AI settings, especially for heating/cooling.
- Enjoys smart security & convenience features (lights, cameras).
- Finds smart home ecosystems fragmented (Nest, Ring, and Alexa don't fully sync).

Thoughts on AI & Automation

"AI-driven thermostats help, but they need better adaptability. I still adjust mine every day."
- Wants better AI personalization.
- Finds energy tracking features useful but not engaging.

What Would Improve His Experience?
- More personalized AI that adapts without needing frequent manual changes.
- A single app to control multiple smart home brands.
- Gamified energy challenges to make savings more engaging.

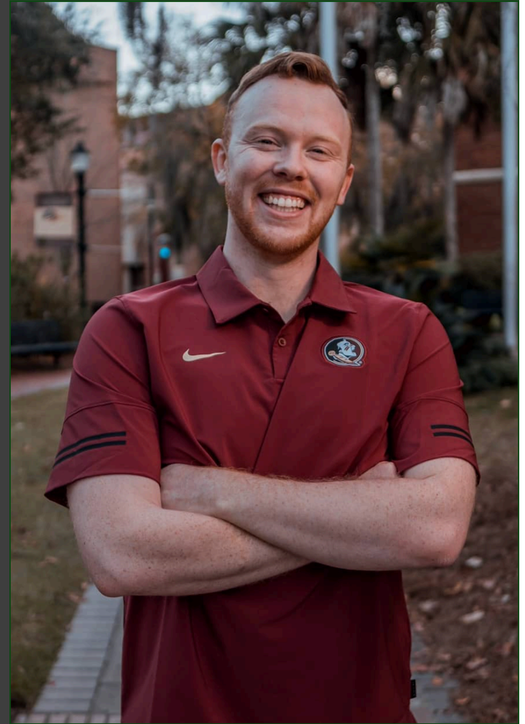
Cameron, 31
Renter, Tampa Bay

Background & Home Setup
- Rents a one-bedroom apartment and lives alone.
- Uses Google Home, smart power strips, and smart plugs.
- Interested in sustainability but has no major financial incentive to invest in smart energy tech.=

Experience with Smart Home Tech
"I use smart plugs for convenience, but I don't track energy savings much. If I got rent discounts for saving energy, I'd care a lot more."
- Likes smart home convenience but doesn't track energy efficiency.
- Finds energy-saving efforts feel invisible & unrewarding.
- Would engage if savings were tied to real financial benefits.

houghts on AI & Automation
"AI is great for small things like turning my lights on when I enter, but for big things like heating? I don't trust it."
- Skeptical of AI taking full control.
- Wants smarter, automated power-saving modes that require zero effort.

What Would Improve His Experience?
- Financial incentives (lower rent, bill credits) for renters using smart energy solutions.
- Automated "low-power mode" features that don't require constant adjustments.
- Better visibility on how much energy his small adjustments are actually saving.



Delaney, 23
Renter, Savannah

Background & Home Setup
- College student renting a small apartment.
- Uses Amazon Alexa, smart lights, and smart power strips.
- Prefers convenience and entertainment over energy efficiency.

Experience with Smart Home Tech
"I like tech that makes life easier. Saving energy is cool, but I mostly just use my smart home for fun."
- Smart tech is primarily for comfort & entertainment.
- Would be more interested in saving energy if it was gamified.

Thoughts on AI & Automation
"I don't want AI making decisions for me, but I'd use a 'smart savings challenge' if it was fun."
- Open to smart energy tech, but only if it's interactive.
- Finds current energy-saving interfaces too technical & boring.

What Would Improve Her Experience?
- Gamified sustainability challenges (like a daily energy-saving leaderboard).
- More renter-friendly automation tools (non-permanent setups).
- Better UI/UX for energy savings (simple, fun dashboards).

Santiago, 29
Homeowner, New York

Background & Home Setup
- Owns a townhouse with his partner.
- Uses Apple HomeKit, Nest Thermostat, smart lights, and solar panels.
- Prefers full automation but struggles with integration across brands.

Experience with Smart Home Tech
"I want everything to work together, but I still need three apps to control my home."
- Enjoys fully automated setups but finds smart home fragmentation frustrating.
- Invested in solar power but wants better energy tracking tools.

Thoughts on AI & Automation
"AI should handle energy efficiency in the background—I shouldn't have to think about it."
- Wants seamless, cross-platform automation.
- Would like better energy usage reports integrated into his daily routine.

What Would Improve His Experience?
- A single dashboard for all smart home devices.
- More proactive energy reporting (not just monthly stats).
- Energy-saving presets that sync across different brands.

Terri, 69
Homeowner, Tallahassee

Background & Home Setup
- Retired and owns a large suburban home.
- Uses basic smart home features (thermostat, smart security).
- Finds smart home systems overwhelming and prefers simple, manual control.

Experience with Smart Home Tech
"I don't need an app to turn my lights off. A switch works just fine."
- Prefers traditional methods over smart home automation.
- Finds smart home apps too complicated.

Thoughts on AI & Automation
"I worry about security and data collection. I don't trust AI to control my home."
- Concerned about privacy & data collection.
- Finds smart home technology intimidating & unnecessary.

What Would Improve Her Experience?
- Simpler UI with one-button controls.
- Better privacy settings (clear data transparency).
- Hands-free energy automation without needing to tweak settings.

Homeowners

"My kids don't love smart home automation. They sometimes get frustrated when lights shut off automatically if they've been quiet in a room for too long."

Tamara, 51
Homeowner, Savannah

"I swear my smart speaker is listening to my conversations. One day, I complained about my old vacuum, and the next day, I got bombarded with ads for new ones."

Justin, 52
Homeowner, Savannah

"My energy app keeps telling me I use 'more electricity than 90% of similar households.' I feel like I'm failing an exam I never signed up for."

Santiago,
Homeowner, New York

Renters

Renters often lack the knowledge and resources to effectively reduce energy consumption or lower costs, despite having a genuine need for it due to limited access to supportive infrastructure.

Anushka, Cameron & Delaney
Renters

Through my interviews with renters, I uncovered a critical gap—many lack the knowledge, resources, and infrastructure to effectively reduce energy consumption, even though they would benefit the most from cost savings. Despite their interest in sustainability and efficiency, they often feel disconnected from smart home solutions due to landlord restrictions, high costs, and lack of control over home infrastructure.

This realization became my North Star, shaping the direction of my entire project. What started as a broad exploration of smart home adoption pivoted into solving this renter-specific challenge—how can accessible, non-invasive, and budget-friendly smart solutions empower renters to take control of their energy use?

This market gap represents an untapped opportunity, and from this point forward, my research and ideation focused on bridging that gap through portable, renter-friendly smart home innovations.

Key Insights

Background & Home Setup

- Owns a townhouse with his partner.
- Uses Apple HomeKit, Nest Thermostat, smart lights, and solar panels.
- Prefers full automation but struggles with integration across brands.

Smart Thermostats & Plugs Have the Most Impact	Users reported 12–20% reductions in electricity bills when using automated heating, cooling, and smart plugs to reduce wasted power.
Users Still Override Automation Frequently	Despite adopting smart home systems, most users manually adjust settings when automation doesn't meet their preferences.
Gamification Drives Energy Savings	Families who turn energy tracking into a competition see higher energy savings, as kids and adults actively try to "win" by reducing usage.
Privacy Concerns Are Growing	Many users suspect smart home devices track conversations and disable data-sharing features to protect their privacy.
Smart Homes Sometimes Backfire	From thermostat wars to haunted smart lights, smart home automation can sometimes cause unexpected frustrations rather than convenience.

04. UNDERSTAND AND DEFINE

After conducting interviews and behavior journal analysis, I had a large volume of qualitative data—a mix of direct quotes, recurring frustrations, and user needs. To make sense of these insights, I used affinity mapping, a method that allowed me to group related findings into core themes and identify patterns across different user segments.

My Affinity Mapping Process

01 Extracting Key Insights – Reviewed interview transcripts and behavior journals, noting recurring pain points, frustrations, and opportunities.

02 Clustering Themes – Grouped similar insights to identify patterns in user behavior and concerns, refining them into clear themes.

03 Identifying Core Issues – Found underlying market gaps.

04 Turning Insights into Innovation – Mapped solutions to key issues.

AFFINITY MAPPING OF USER INTERVIEWS

User Trust & AI Automatio

Core Issue: AI-driven automation is not universally trusted—users want a balance between automation and manual control.

- Justin (52, Homeowner, Savannah) & Tamara (51, Homeowner, Savannah): Frequently override AI settings because they feel they lack control and the system makes incorrect adjustments.
- Santiago (29, Homeowner, NY): Finds AI automation useful but ineffective without manual override options.
- **Overall Insight:** AI shouldn't replace human decision-making, but rather enhance user control through predictive but adaptable automation.

Opportunities for Innovation:

- **Hybrid AI Systems:** Combine AI-driven predictions with user-defined preferences to increase trust and usability.
- **Transparent AI Decision-Making:** Show users why automation makes specific decisions (e.g., "Adjusting temperature to 72°F because it matches your preferred evening comfort").
- **Voice-Control & Gesture Overrides:** Allow instant manual overrides through voice commands or gesture-based interactions.

Work-Life Balance & Predictive Comfort

Core Issue: Smart homes should automate comfort settings based on user routines rather than just fixed schedules.

- Delaney (23, Renter, Savannah): Wants her home to adjust automatically based on her work and relaxation schedules.
- Santiago (29, Homeowner, NY): Would benefit from AI-driven adjustments after the gym, such as activating air purifiers and cooling settings.
- **Overall Insight:** Smart homes should predict when users need different environments and adjust dynamically without requiring manual input.

- **Opportunities for Innovation:**
- **Predictive AI Climate Control:** Learns daily patterns and automatically adjusts heating, cooling, and lighting to optimize both energy savings and comfort.
- **Adaptive Room Zoning:** Uses motion sensors and occupancy data to control which rooms need temperature adjustments, rather than heating/cooling an entire house.
- **AI-Powered Stress Detection:** Uses wearables or biometric sensors to adjust lighting, music, and air quality based on stress levels.

Emerging Technologies & Future Opportunities

Core Issue: Next-generation hardware & AI innovations could revolutionize smart home experiences beyond today's solutions.

New possibilities that could redefine smart living:

- **Graphene-Based Thermal Materials** – Ultra-thin smart fabrics that regulate temperature without needing heavy HVAC energy usage.
- **AIoT (AI + Internet of Things) Chips** – Microchips that predict behavior & optimize devices without needing app controls.
- **Self-Powered Sensors** – Nano-sensors that harvest energy from movement or heat, making them battery-free and maintenance-free.
- **Holographic Interfaces** – No more physical screens—interactive home control via air gestures and voice commands.
- **Bio-Sensing Smart Homes** – Uses wearables (smart rings, watches, implants) to measure stress & adjust environments accordingly.

AFFINITY MAPPING OF USER INTERVIEWS

Renters & Smart Home Access

Core Issue: Renters want smart home benefits but face restrictions in modifying infrastructure.

- Anushka (26, Renter, Boston), Cameron (31, Renter, Tampa Bay), & Delaney (23, Renter, Savannah): Interested in smart home tech but cannot install permanent devices like smart thermostats, solar panels, or smart wiring.
- **Overall Insight:** Renters need flexible, temporary solutions that provide seamless automation without requiring modifications.

Opportunities for Innovation:

- **Portable Smart Home Kits:** Renters could lease plug-and-play smart home tech that can be returned or transferred when they move.
- **Smart Magnetic Panels:** Modular stick-on smart panels can control lighting, heating, and security without requiring rewiring.
- **Retrofitting AI Smart Plugs & Sensors**: Small clip-on smart sensors can be attached to existing appliances (e.g., ACs, heaters, fans) to give them smart capabilities.

Seamlessness & System Integration

Core Issue: Users are frustrated by fragmented smart home systems—they want an all-in-one solution.

- Santiago (29, Homeowner, NY) & Tamara (51, Homeowner, Savannah): Managing multiple smart home apps (e.g., Alexa, Nest, Hue) is frustrating and leads to disengagement.
- **Overall Insight:** The smart home experience needs to be fully integrated—users want one unified interface instead of juggling multiple apps.

Opportunities for Innovation:

- **Universal Smart Home Dashboard:** A cross-brand home automation platform that syncs Nest, Ring, Alexa, Hue, and other devices into one seamless experience.
- **Smart Home OS (Operating System):** AI-powered software that auto-detects new devices and integrates them without manual setup.
- **One-Tap Device Syncing:** Users should be able to sync all their smart home devices with a single tap, rather than going through complex setups.

Gamification & Behavioral Incentives

Core Issue: Different users have different motivations for engaging with smart home energy savings.

- Cameron (31, Renter, Tampa Bay): Wants financial incentives like rent discounts or utility bill credits to motivate energy-efficient behaviors.
- Tamara (51, Homeowner, Savannah): Prefers eco-impact tracking over financial rewards, as she values sustainability awareness.
- **Overall Insight:** Gamification strategies must align with user preferences—renters are more financially driven, while homeowners are more sustainability-driven.

Opportunities for Innovation:

- **Dual Reward Models:** Users can choose between financial rewards (bill savings, discounts) or eco-rewards (impact tracking, carbon credits).
- **Social Energy Challenges:** Households could participate in monthly challenges to compete in energy savings and earn badges, discounts, or exclusive access to green products.
- **Real-Time Energy Feedback:** AI should gamify energy savings by showing how many trees, water gallons, or dollars were saved daily.

Aspect	Energy Efficiency Focus (Savings, AI, Optimization)	Comfort & Convenience Focus (Ease, Control, Daily Use)	Overlap (Seamless Smart Home Experience)
Automation & Control	Justin (52, homeowner) trusts automation but frequently overrides settings manually.	Anushka (26, renter) prefers smart lighting & security over energy tracking.	Santiago (29, homeowner) wants automation that adapts to his personal routine.
Gamification & Engagement	Cameron (31, renter) would engage more if incentives (e.g., lower rent, rebates) existed.	Delaney (23, renter) prefers fun, interactive controls like voice assistants.	Tamara (51, homeowner) suggests eco-rewards for reducing monthly consumption.
Adoption Barriers	Terri (69, homeowner) finds AI overwhelming, preferring manual settings.	Anushka (26, renter) can't install permanent fixtures, limiting participation.	Delaney (23, renter) wants renter-friendly, plug-and-play options.
Cost Savings vs. Lifestyle	Santiago (29, homeowner) sees clear financial benefits from solar panels & energy tracking.	Cameron (31, renter) values lifestyle convenience (smart speakers, climate control).	Justin (52, homeowner) integrates both, balancing comfort with savings.
Integration Issues	Tamara (51, homeowner) finds smart devices from different brands hard to sync.	Terri (69, homeowner) avoids complex integrations due to a lack of technical knowledge.	Santiago (29, homeowner) wants a single app that controls all devices smoothly.

Figure 4.1

This table (figure 4.1) illustrates the different priorities and challenges that users face when adopting smart home technologies

This phase of my research was a deep dive into contradictions between existing research and real user experiences, helping me identify market gaps and innovation opportunities. The following sections summarize key findings, their implications, and how they refine my project direction.

Contradictions in Research vs. User Interviews

What I Discovered:
Through user interviews, I found that real-world behaviors often conflicted with research-based assumptions about smart home adoption, AI trust, and engagement strategies **(figure 4.2.)**

Research Claim	User Reality	Implication
AI energy management is most effective when untouched.	Users override AI frequently. They want manual control over automation.	AI should offer adaptive automation, allowing users to tweak settings without overriding the system entirely.
Renters are slower to adopt smart home tech due to installation barriers.	Renters use smart assistants and plug-in devices but struggle with permanent fixtures (e.g., thermostats, solar panels).	Renters need portable, modular, non-invasive solutions that don't require landlord approvals.
Energy-saving incentives (eco-rewards, discounts) increase engagement.	Financial incentives drive renters, while homeowners prefer eco-tracking.	Gamification strategies must be personalized—renters want cost savings, homeowners seek impact tracking.
Users prefer seamless integration between smart devices.	Managing multiple apps is frustrating (e.g., juggling Alexa, Nest, Hue).	A unified smart home dashboard is needed to simplify control and integration.

Figure 4.2

Key Takeaways & Untapped Opportunities

High Interest but Limited Control for Renters

- Renters are eager to adopt smart home solutions, but landlord restrictions and infrastructure limitations hold them back.
- **Opportunity:** Develop portable smart tech that doesn't require permanent installation (e.g., AI-powered plug-in energy monitors).

Incentive Structures Must Align with User Lifestyles

- Renters prioritize financial savings (lower rent, bill reductions), while homeowners value environmental impact tracking.
- **Opportunity**: Create dual-incentive models—financial rewards for renters, eco-tracking for sustainability-driven users.

AI-Driven Automation Requires Greater User Trust

- Users override automation when they feel out of control—they don't want AI making decisions without transparency.
- **Opportunity**: Hybrid AI automation that offers user-guided overrides while maintaining smart energy optimizations.

Fragmented Smart Home Ecosystems Hinder Seamlessness

- Managing multiple apps and devices frustrates users—they want a unified smart home interface.
- **Solution:** Develop a cross-compatible smart home OS to sync multiple brands and devices in one platform.

Triangulating Insights

This table **(figure 4.3)** illustrates how I systematically analyzed insights by combining qualitative and quantitative research methods. Using triangulation, I integrated multiple data sources to cross-validate findings, ensuring a comprehensive and reliable understanding of smart home adoption trends.

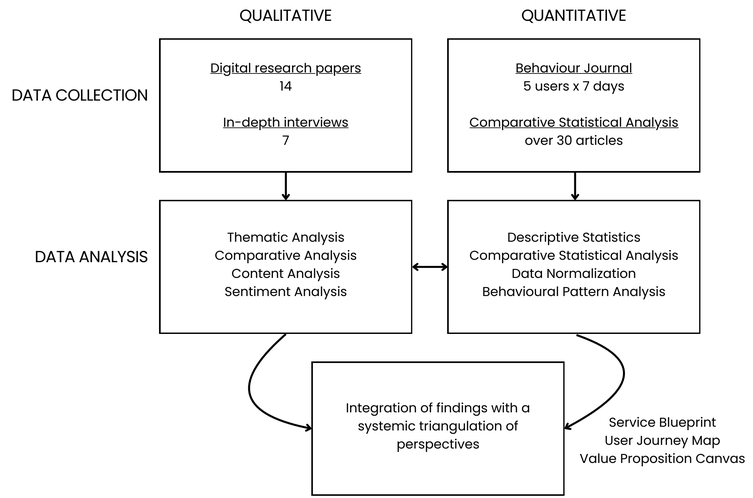
My Process for Systemic Triangulation

To ensure a well-rounded and validated understanding of smart home adoption, I used a three-pronged approach:

- **Secondary Research Findings** → Sourced credible reports, case studies, and statistical data on smart home energy efficiency, AI adoption, and gamification.
- **Behavior Journals** → Captured real-world user behaviors over seven days, tracking energy habits, automation preferences, and sustainability awareness.
- **User Interviews** → Gained deep qualitative insights into pain points, motivations, and real-life interactions with smart home systems.

After collecting the data, I conducted comparative analysis, looking for alignment, contradictions, and emerging trends across all three research types.

Figure 4.3



Multi-Method Analysis for Depth & Accuracy

- **Thematic Analysis** → Identified recurring themes, pain points, and opportunities from user interviews and behavior journals.
- **Comparative Analysis** → Compared primary research findings against existing literature to uncover contradictions or knowledge gaps.
- **Content & Sentiment Analysis** → Analyzed user feedback and behavioral data to assess emotional reactions to smart home experiences.
- **Descriptive & Statistical Analysis** → Used quantitative data to measure behavioral patterns, adoption rates, and cost-benefit trade-offs.
- **Data Normalization** → Standardized findings across different research formats to extract coherent conclusions.
- **Behavioral Pattern Analysis** → Mapped how users interact with smart home technologies in their daily lives.

How These Methods Were Applied in the Final Insights

- Cross-referencing qualitative themes with quantitative energy savings data provided well-rounded conclusions.
- Identified opportunities for AI optimization, financial incentives, and policy recommendations based on combined research.
- Ensured that behavioral engagement insights were supported by statistical energy savings data.

Consolidated Insights from Secondary Research, Behavior Journals, and User Interviews

01. Automation & Energy Efficiency: Reality vs. Expectations

Research vs. User Reality
Research Claim: AI-driven automation optimizes energy savings when left untouched.
User Reality: Users frequently override AI automation (Justin & Tamara, homeowners), preferring manual control over automated settings.

Key Insights:
- AI automation must be predictive yet adaptable—Users should be able to manually adjust settings while still benefiting from AI-driven optimizations.
- Comfort outweighs energy savings for many users—AI should adjust based on behavioral patterns instead of imposing rigid efficiency rules.
- Smart homes should feel effortless—Automation should integrate into routines without making users feel controlled.

Design Implications:

- Develop hybrid AI models that adapt to individual user preferences while optimizing energy use.
- Improve transparency in automation—Users should see why AI makes decisions and easily tweak settings to maintain comfort.
- Prioritize intuitive automation—AI should adjust lighting, temperature, and energy use based on behavioral patterns without requiring manual input.

02. Privacy Concerns: A Barrier, But Not the Biggest One

Research Claim: Privacy concerns significantly hinder smart home adoption (48% of users disable tracking features).
User Reality: Privacy is a concern but not the main adoption barrier—usability, integration, and comfort take priority.

Key Insights:
- Users accept AI tracking if it enhances convenience—They want to know how their data is used, but comfort and ease of use matter more.
- Trust is key—Users will rely on AI automation if they feel in control and the system adapts to their preferences.

Design Implications:
- Offer clear data privacy controls—Let users opt-in or customize what data is collected.
- Build trust through explainability—Use real-time privacy alerts to show what data is being used at any given moment.
- Balance privacy with intuitive automation—Minimize data collection while retaining AI's ability to enhance user comfort through pattern recognition.

03. Gamification & Incentives: What Actually Works?

Research Claim: Gamification increases energy savings—households using gamified energy tracking reduced consumption by 9% more than non-gamified households.
User Reality: Renters prefer financial savings (Cameron, 31), while homeowners prefer eco-tracking (Tamara, 51).

Key Insights:
- Gamification works best when personalized—Some users are motivated by financial rewards, while others prefer environmental impact tracking.
- Users engage more when energy savings feel tangible—AI should provide real-time energy feedback that translates consumption into practical terms (e.g., "You saved enough energy to power your laptop for 10 hours").

Design Implications:
- Create a dual-incentive model—Let users choose between financial savings (rent discounts, rebates) or impact-tracking rewards (carbon credits, sustainability badges).
- Improve engagement through behavioral insights—Gamify energy tracking based on past behavior, rewarding sustainable habits.
- Ensure energy tracking is intuitive and non-intrusive—Real-time updates should feel like helpful nudges, not nagging alerts.

04 Renters & Accessibility: The Biggest Market Gap

Research Claim: Renters adopt smart home tech at a slower rate due to installation barriers.
User Reality: Renters (Anushka, Delaney) are highly interested in smart home tech but lack access to non-invasive solutions.

Key Insights:
- here is high interest in smart home solutions for renters, but they need portable, modular, and non-permanent options.
- Traditional smart home tech is designed for homeowners—renters don't have the ability to install smart thermostats, solar panels, or wired security systems.

Design Implications:
- Develop renter-friendly, plug-and-play smart home kits—E.g., stick-on smart panels, portable sensors, AI-powered clip-on adapters for appliances.
- Create subscription-based smart home solutions—Renters can lease smart devices without long-term commitments.
- Ensure renter-friendly solutions integrate seamlessly—They should work without modifying the home's infrastructure.

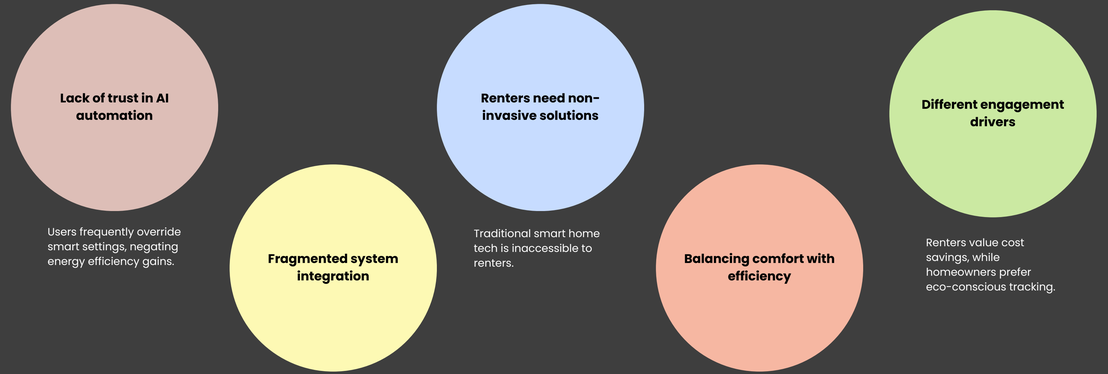
05. Smart Home Fragmentation: The Need for a Unified System

Research Claim: Users value seamless integration across smart home brands.
User Reality: Managing multiple smart home apps (Alexa, Nest, Hue, Ring) is frustrating and reduces engagement (Santiago & Tamara).

Key Insights:
- Users want a single dashboard—They don't want to juggle multiple apps and settings for different devices.
- Smart home ecosystems remain fragmented, forcing users to manually sync devices from different brands.

Design Implications:
- Develop a unified smart home platform that integrates various brands into a single control system.
- Allow one-tap device syncing—Users should be able to sync all their smart home devices without complex setups.
- Ensure smart home controls remain intuitive—Reduce cognitive load by automating repetitive tasks without disrupting user preferences.

Challenges



Anticipated Impact

When I look at everything I've researched, analyzed, and synthesized, one thing is clear—smart home technology isn't just about energy savings or automation; it's about creating an intuitive, effortless, and human-centric living experience.
Initially, I assumed that energy efficiency would be the core driver of smart home adoption, but my research proved otherwise. People prioritize comfort, ease of use, and seamless integration over pure energy savings. This realization shifted my approach—I started focusing on how AI could enhance everyday living, rather than just optimize energy use.

- **AI Must Be Adaptive & Intuitive** → I strongly believe that AI should work for users, not the other way around. Instead of requiring constant manual adjustments, it should learn user habits, anticipate needs, and adapt seamlessly. Comfort isn't just about temperature—it's about lighting, air quality, routines, and minimizing the cognitive load of managing a home.

- **A Single Unified Platform is Needed** → One of the most frustrating things I discovered from my interviews was how fragmented smart home systems are. Users don't want to jump between multiple apps just to control their devices. If smart homes are truly "smart," they should work in harmony, not in isolation. My goal is to design a system that makes interactions fluid, simple, and frictionless.

- **Comfort Must Drive Engagement** → Sustainability can't be forced on users—it needs to be a byproduct of an enjoyable experience. If AI makes a home feel better, people will naturally engage with its sustainability features. This means finding ways to make automation non-intrusive, non-disruptive, and customizable so it enhances comfort while reducing waste.

- R**enters Need Plug-and-Play Smart Home Solutions →** Homeowners have the luxury of installing permanent systems, but renters? They're left out. I saw a huge market gap here, and I truly believe smart home tech needs to be accessible to people who move frequently or don't own their living spaces. That's why I'm exploring portable, subscription-based solutions—ones that don't require landlords' permission or permanent changes to infrastructure.

Moving Forward

In moving forward, my focus is on creating a smart home experience that is intuitive, seamless, and optimized for real human behavior. Smart technology should feel invisible and effortless, not like an extra responsibility. If I can design solutions that eliminate friction, enhance comfort, and make energy savings feel natural, then I know I'm heading in the right direction.

PERSONA ONE

The Eco-Conscious Homeowner

Name: Tamara Davis
Age: 51
Location: Savannah, GA
Occupation: Marketing Director
Household: Married, 2 kids (ages 17 & 20)
Tech Comfort Level: Moderate
Sustainability Interest: High

Motivations:
- Wants a sustainable home with reduced energy consumption.
- Values long-term savings from smart technology.
- Prefers automation but wants manual control when needed.
- Enjoys tracking carbon footprint reductions.

Pain Points:
- Finds smart home integration frustrating due to brand incompatibility.
- Struggles with AI automation overriding manual settings.
- Wants eco-impact tracking but feels most systems focus on cost savings.

Opportunities for Innovation:
- Hybrid AI models that allow user-defined automation preferences.
- A unified smart home dashboard to control all devices in one place.
- Sustainability dashboards that show energy savings in terms of environmental impact.

image credit: chatgpt.com

PERSONA TWO

The Budget-Conscious Young Renter

Name: Cameron Wright
Age: 31
Location: Tampa Bay, FL
Occupation: Software Engineer
Household: Rents a 2-bedroom apartment with a roommate
Tech Comfort Level: High
Sustainability Interest: Moderate

Motivations:
- Wants cost savings on electricity and rent.
- Prefers smart devices that don't require permanent installation.
- Enjoys tech-driven convenience but isn't deeply invested in sustainability.
- Open to gamification and financial incentives for energy efficiency.

Pain Points:
- Renting restrictions prevent installation of smart thermostats or solar panels.
- Existing smart home tech is too expensive—needs low-cost, flexible options.
- Prefers direct financial incentives over sustainability tracking.

Opportunities for Innovation:
- Plug-and-play smart home kits that don't require landlord approval.
- Subscription-based smart home solutions for low-cost adoption.
- Rent discount or cashback incentives for sustainable behavior.

PERSONA THREE

The Tech-Savvy Early Adopter

Name: Claudia Martinez
Age: 29
Location: New York, NY
Occupation: Product Manager in a Tech Startup
Household: Lives alone in a high-rise apartment
Tech Comfort Level: Very High
Sustainability Interest: Moderate

Motivations:
- Wants a fully automated home with AI-driven personalization.
- Values seamless smart home integration with a single control system.
- Prefers data-driven insights on energy use.
- Enjoys customizable automation for convenience.

Pain Points:
- Frustrated with fragmented smart home ecosystems (e.g., Nest, Hue, Ring requiring separate apps).
- Finds AI automation inconsistent—sometimes overrides settings manually.
- Wants more real-time insights about his energy use.

Opportunities for Innovation:
- A Smart Home OS that syncs all devices seamlessly.
- AI-driven comfort adjustments that predictively adjust lighting, temperature, and air quality based on personal routines.
- Gesture-based & voice-controlled overrides to balance automation and manual control.

SERVICE BLUEPRINT

Initial Persona and Service Blueprint

Very interesting. Let us discuss.

Wondering if any of the attributes ought to be connected to specific devices listed.

I went through multiple iterations of both personas and the service blueprint, refining them continuously as new insights arose and affinity mapping progress. As this is a process book, I am showcasing the initial version of my service blueprint on the right, followed immediately by the refined version **(figure 4.3)**—demonstrating the evolution of my thinking and the impact of deeper research.

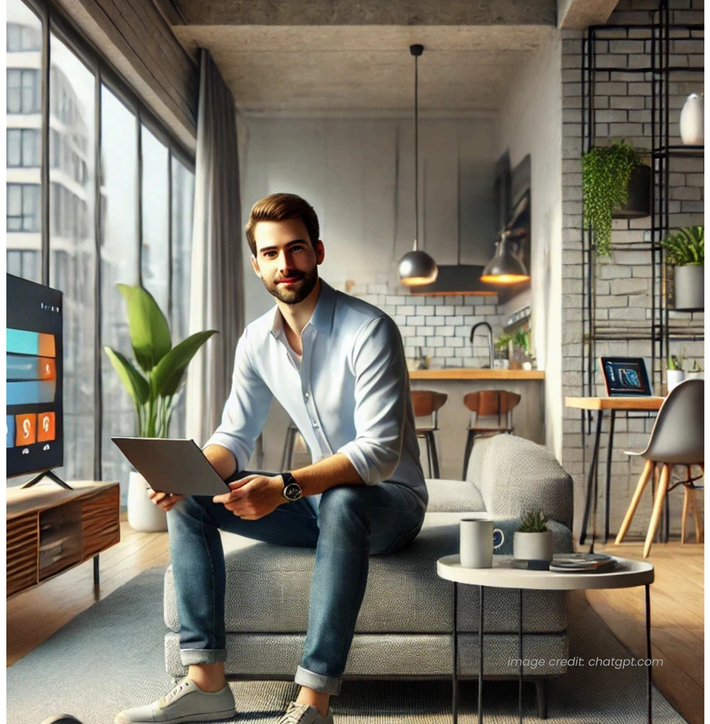
Alex Carter – The Smart Home User
Age: 32
Living Situation: **Renter**, urban apartment
Occupation: UX Designer, works remotely 3x/week
Sustainability Attitude: Cares about the environment but prioritizes convenience

Pain Points:

- Finds energy dashboards too abstract; prefers real-world benefits (e.g., discounts, rewards).
- Doesn't trust full automation; often overrides smart home settings.
- Wants cross-brand device integration but struggles with multiple apps.

Needs & Goals:

- Automated energy-saving without sacrificing comfort.
- A fun, engaging way to track sustainability impact.
- Integration of public transport, food, and secondhand shopping into smart home rewards.



Initial Service Blueprint Draft

	Waking Up	Leaving Home	Returning Home	Night Routine
Customer Actions (What the user does)	Adjusts thermostat manually or via voice., Asks smart speaker for weather updates., Turns on lights (manual or motion-activated).,Checks daily sustainability challenge.	- Activates "Away Mode" on the app.,Checks if all devices are off via app., Arms security system., Logs eco-friendly commute (e.g., biking, public transit) for reward points.	Uses smart lock or mobile app to unlock the door, Lights and thermostat adjust automatically., Prepares dinner with smart appliances., Engages in an energy-saving challenge (e.g., low-energy cooking).	Uses voice commands to turn off devices., Checks energy usage report for the day., Looks at accumulated incentives for eco-friendly actions., Activates security system.
Touchpoints (Where interactions happen)	- Mobile app for thermostat & lights control., Voice assistant interfaces., Motion sensors activating lights, Morning sustainability challenge displayed on dashboard.	- Mobile app for smart home mode selection., Security system notifications, Smart plugs automating power-off sequences, Eco-reward system updates user points for choosing green transportation.	Smart locks & mobile authentication, Appliance dashboards, Predictive AI adjusting thermostat., Gamified cooking challenge encouraging low-energy meals.	- Smart speaker for shutdown commands., Energy reports & sustainability insights, Security camera & alarm integration., Leaderboard comparing energy savings with friends/neighbors.
Frontstage Interactions (User Experience & Interface)	- Smart thermostat responds to voice/app commands., Lights turn on automatically based on motion., Smart speaker provides weather & sustainability updates.,Energy dashboard displays "Today's Green Goal" (e.g., reducing AC use).	- Smart devices send confirmation (lights off, thermostat on eco-mode)., Mobile app displays energy savings and earned eco-rewards., Security system sends status confirmation.	- Smart lock confirms authentication via app., Lights gradually brighten to preset levels. , Oven preheats automatically based on schedule., Home app suggests a "Low Carbon Meal Challenge" based on available food & energy consumption.	- Smart thermostat switches to night mode., Mobile app provides energy-saving insights., Security system arms automatically, Gamified energy leaderboard displays ranking among friends/neighbors.
Backstage Processes (Automation & AI Operations)	- AI detects wake-up patterns and pre-heats rooms. - Motion sensors detect movement and adjust lighting. - Weather APIs provide real-time updates. - AI recommends morning sustainability goals based on past behavior.	- AI predicts energy use and adjusts thermostat accordingly. - Security system integrates real-time camera feed. - Smart plugs shut off non-essential devices. - System tracks public transport/biking usage for eco-reward points.	- AI recognizes user's arrival time patterns. - Device-to-device communication ensures seamless experience. - Kitchen appliances sync with user-preferred settings. - App suggests sustainable evening habits (e.g., using smart blinds to retain warmth instead of heating).	- AI analyzes energy patterns and suggests savings for the next day. - Automated system updates occur overnight. - Smart cameras activate night vision mode. - Eco-rewards update, showing available incentives for public transport, flea markets, or zero-waste stores.
Support Systems (Infrastructure & Energy Providers)	- Cloud servers process data & update AI learning models. - Smart home brand firmware updates ensure system stability. - Sustainability partner brands (local farmers, secondhand stores) integrate with reward system.	- Power companies integrate with energy demand response programs. - Cloud servers handle remote monitoring & security alerts. - Local governments & transit systems provide data-sharing for eco-reward tracking.	- Encrypted authentication via cloud security. - Device manufacturers provide software updates for seamless integration. - Smart energy companies collaborate with local businesses for additional sustainability challenges.	- Smart home brands push software updates. - Cloud-based servers sync daily reports and security logs. - User earns a discount or free public transport ride for reducing energy use by X% over the week.
Opportunities	Personalized green challenges – Suggest daily or weekly sustainability actions based on user habits., Improved voice assistant reliability – Reduce misinterpretation of energy-saving commands.,Seamless integration of multiple brand devices to prevent incompatibility issues.	Automate Eco-Mode based on geolocation – System should detect when users leave home and activate automatically., Better UI/UX for energy dashboards – Users should see energy savings in real-world incentives (e.g., transit rewards, local discounts)., Reduce security notification fatigue – Introduce customized alert settings for user preferences.	Refine smart lock response times – Address delayed unlocking issues, especially in rental homes., Introduce real-world rewards for energy savings – Partner with local businesses, farmers' markets, and transit providers.	Adaptive night routines – AI should adjust device shutoff schedules dynamically based on user habits., Social engagement through gamification – Allow users to track collective energy savings and compete with neighbors, Privacy-first incentive tracking – Users should have control over what data is shared to earn rewards.

Refined Service Blueprint

Stage	Customer Actions	Touchpoints	Frontstage Interactions	Backstage Processes	Support Systems	Opportunities
1- Waking Up – AI-Powered Morning Routine	- Lights gradually brighten before alarm. - Thermostat adjusts for a comfortable wake-up temp. - Smart speaker updates user on weather, schedule & sustainability challenge. - Morning eco-dashboard suggests optimized energy use (e.g., delaying coffee maker to avoid peak grid usage).	- Smart lighting & thermostat - Smart speaker dashboard - Energy app with morning sustainability insights.	- Adaptive lighting based on wake-up patterns. - Smart speaker delivers a short, personalized morning briefing. - Dashboard highlights real-time energy efficiency tips.	- AI detects user's wake-up habits & pre-adjusts settings. - Predictive AI optimizes device timing based on usage trends.	- Smart home cloud system updates overnight for seamless experience. - Energy provider syncs with demand response program.	-Smart blinds integration – Optimize natural light use. -Adaptive energy use goals – Recommend small daily energy-saving actions.
2- Leaving Home – Intelligent Power Management	- Smart home enters "Away Mode" automatically. - System shuts off non-essential devices (lights, plugs, appliances). - Security system arms automatically. - User gets an update if any device is left on.	- Smart home mobile app & geofencing triggers. - Security notifications & eco-reward system updates.	- One-tap "Away Mode" activation in the app. - Security cameras confirm doors are locked. - Energy dashboard displays estimated savings from energy-efficient settings.	- AI detects user departure & activates smart mode. - Smart plugs & appliances sync with remote automation. - System logs eco-friendly actions for gamified tracking.	- Cloud-based automation handles remote monitoring. - Local utility company adjusts home energy based on grid demand.	-Better geolocation tracking – Automate "Away Mode" based on distance from home. -Seamless security alerts – Reduce notification overload with AI-driven filtering.

Figure 4.3

Stage	Customer Actions	Touchpoints	Frontstage Interactions	Backstage Processes	Support Systems	Opportunities
3- Returning Home – Adaptive Comfort & Personalization	- Home senses arrival and gradually adjusts lighting & temperature. - Security system auto-disarms. - Kitchen pre-heats based on planned meals. - Smart home welcomes user with personalized ambient settings (music, lighting, scent).	- Smart lock & geofencing detection. - AI-powered appliance presets. - Voice assistant for instant adjustments.	- Lights turn on at preset warmth levels. - AI-driven meal planning suggests sustainable cooking options. - Smart speaker welcomes user based on personalized settings.	- AI detects user arrival & adjusts conditions accordingly. - Kitchen appliances sync with grocery list & low-energy cooking recommendations.	- Secure cloud authentication for smart lock & home access. - Smart grid syncs energy use with renewable availability.	-Refine AI arrival detection – Predict adjustments dynamically instead of fixed routines. -Enhance sustainable meal prep suggestions – Low-energy cooking methods.
4- Night Routine – Seamless Transition to Rest Mode	- AI lowers brightness & transitions to night mode. - Security system auto-activates based on user schedule. - Smart thermostat adjusts for sleep comfort. - Energy report shows daily efficiency insights & eco-rewards progress.	- Smart speaker shutdown commands. - Mobile app sleep tracking & eco-impact summary. - Security app notifications.	- AI transitions devices into low-energy mode. - App displays next-day energy goals. - Security system confirms activation via notification.	- Smart home learns sleep patterns & optimizes heating/cooling. - Predictive AI adjusts room conditions for better sleep quality.	- Night mode settings sync with wearable sleep trackers. - Energy provider integrates with peak reduction programs.	-Improve AI sleep comfort tracking – Integrate with wearable devices. -Nighttime air quality optimization – Suggest adjustments based on sleep patterns.

Figure 4.3

What This Blueprint Addresses

Key Insight / Takeaway	**How the Service Blueprint Addresses It**
Users frequently override AI automation because they don't trust it or it disrupts their comfort.	Hybrid AI Systems: AI doesn't just dictate energy settings—it provides transparency and manual override options, explaining why it made a decision (e.g., "Lowering temp to 72°F because of your usual routine").
Fragmented smart home systems (too many disconnected apps) frustrate users.	Unified Smart Home Dashboard: A single platform integrates all smart home devices (Nest, Hue, Alexa, etc.), eliminating the need for multiple apps.
Renters want smart home benefits but face installation barriers.	Plug-and-Play Smart Home Solutions: Magnetic smart panels, AI-powered appliance adapters, and subscription-based kits offer non-permanent, renter-friendly solutions.
Users engage more when smart home systems personalize their experience.	Predictive AI & Personalization: The system learns user habits and automates settings accordingly, optimizing lighting, temperature, and security without frequent manual input.
Comfort often outweighs energy savings—users prioritize convenience over efficiency.	Seamless Automation for Comfort: AI adjusts settings based on wake-up times, work hours, and relaxation routines, ensuring comfort is never compromised for efficiency.
Gamification increases engagement, but motivation varies—homeowners prefer sustainability tracking, while renters prefer financial incentives.	Dual Reward System: Users choose between eco-rewards (carbon credits, environmental impact tracking) or financial incentives (rent discounts, energy bill savings).

Figure 4.4

UNDERSTAND AND DEFINE | **SERVICE BLUEPRINT**

Key Insight / Takeaway	**How the Service Blueprint Addresses It**
Users don't want to manually control everything—they want an intuitive system that anticipates their needs.	AI Predicts & Adapts: Geofencing, motion sensors, and routine learning allow the home to adjust without user intervention.
People are more likely to engage with energy-saving behaviors if they get real-time feedback.	Gamified Energy Reports: Users see how much energy they saved in real-world terms (e.g., "Your actions today saved the energy equivalent of 4 trees!").
Homeowners with families need smart home features that work for everyone, including kids.	Adaptive Family Settings: AI adjusts automations based on family routines, and kids' activity tracking prevents frustrations like auto-turning off lights when someone is still in the room.
Privacy concerns remain a barrier—many users are hesitant to let AI fully control their home.	Privacy-First AI Customization: Users can opt-out of data collection while still using automation. All AI decisions are explainable and transparent.

Figure 4.4

To create a service blueprint **(Figure 4.3)** that is both unbiased and innovative, I systematically mapped insights from secondary research, user interviews, behavioral journals, and comparative analysis into actionable service features **(Figure 4.4).** This ensured that the blueprint wasn't just theoretical but directly addressed real user behaviors, pain points, and motivations.

This approach allowed me to not only refine the service experience but also identify future opportunities. It cleared up a lot of noise for me personally with the ideation phase.

As I refined my service blueprint **(Figure 4.3)**, I ensured that every anticipated impact was not just included, but seamlessly woven into the user journey. My goal was to remove friction from smart home interactions, increase trust in AI-driven automation, and make energy efficiency effortless—all while keeping the comfort and convenience of users at the center.

One of the most critical takeaways was the realization that users override automation when they don't trust it or when it interferes with their comfort. That's why I prioritized hybrid AI systems—ones that learn from user behavior but still allow manual control.
I also recognized that renters face a unique challenge—they want smart home benefits, but can't install permanent devices. This insight led me to explore plug-and-play solutions, modular smart home kits, and subscription-based models that could make smart technology more accessible.

Finally, I tackled the fragmentation of smart home experiences. Users don't want to juggle multiple apps—they want one seamless system. My blueprint addresses this with a unified smart home dashboard that syncs all devices into a single interface.

This refined service blueprint represents the culmination of user research, behavioral insights, and technological possibilities—a vision for a truly intelligent, user-friendly, and intuitive smart home experience.

VALUE PROPOSITION CANVAS

When I first started working on my Value Proposition Canvas, my goal was to bridge the gap between what renters want in smart home technology and what currently exists in the market. I needed to ensure that my solution wasn't just technologically advanced but also practical, accessible, and intuitive.

This **(figure 4.5)** was a direct reflection of my research synthesis—ensuring that every insight translated into a tangible product or service offering. It wasn't about just listing features but about creating a system that renters would actually adopt.

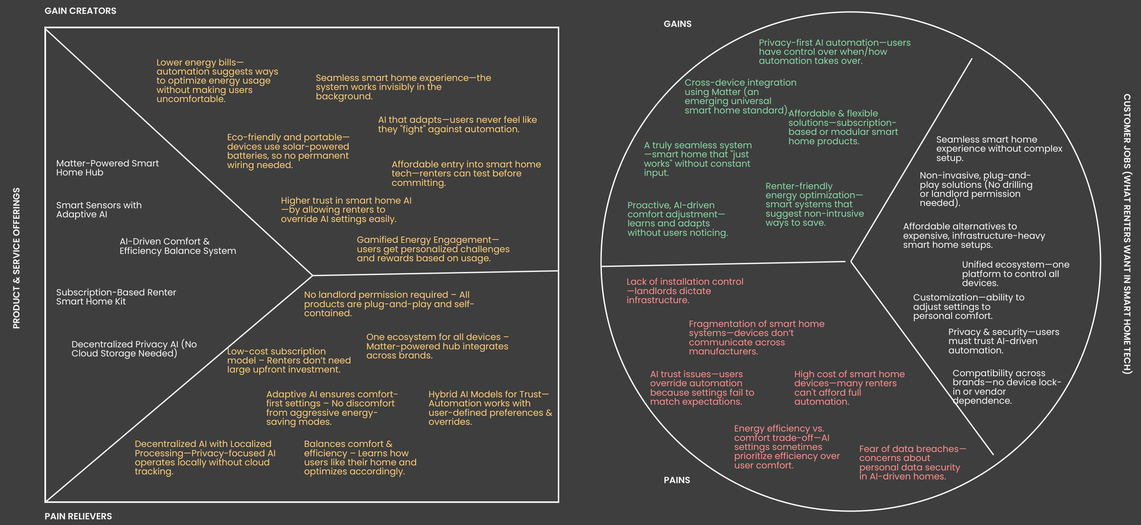


Figure 4.5

Product & Service Offerings

Matter-Powered Smart Home Hub
What it Does → A universal, cross-brand home automation hub that integrates all smart devices seamlessly.
Why It's Needed → Renters struggle with fragmented ecosystems (e.g., Alexa, Google Nest, Hue) and need one centralized system to control everything.
How It Solves the Problem → Uses Matter (the emerging smart home standard) for brand-agnostic device compatibility

AI-Driven Comfort & Efficiency Balance System
What it Does → Ensures energy efficiency without compromising comfort, dynamically adjusting heating, cooling, and lighting.
Why It's Needed → Many smart systems prioritize savings over user comfort, leading users to override automation.
How It Solves the Problem → AI learns from user behavior (e.g., preferred temperatures, lighting moods) and optimizes without needing manual input.

Decentralized Privacy AI (No Cloud Storage Needed)
What it Does → A smart home AI system that processes data locally, removing the need for cloud-based storage.
Why It's Needed → Privacy is a major concern—48% of users disable smart home tracking features due to data concerns.
How It Solves the Problem → AI works on-device, keeping all user data secure and private, eliminating concerns over third-party tracking.

Smart Sensors with Adaptive AI
What it Does → AI-powered sensors that learn user patterns and make predictive adjustments for energy savings & comfort.
Why It's Needed → Users dislike when automation disrupts their comfort (e.g., thermostats making homes too cold at night).
How It Solves the Problem → Balances efficiency with user lifestyle, adapting over time instead of forcing sudden changes.

Subscription-Based Renter Smart Home Kit
What it Does → A low-cost, modular smart home kit that renters can subscribe to monthly instead of buying expensive devices upfront.
Why It's Needed → Renters often can't install permanent smart home systems, and high upfront costs prevent adoption.
How It Solves the Problem → Plug-and-play self-contained devices that require no landlord approval, making smart homes accessible.

Next Steps

With my Value Proposition Canvas refined and backed by research, it was time to translate these insights into tangible concepts. This meant moving from understanding the user's needs to designing real-world solutions that address them.

05.
IDEATION

Before jumping into fully formed solutions, I needed to take a step back and deconstruct what makes a truly intuitive, seamless, and sustainable smart home experience. Rather than forcing an outcome too early, I approached this phase like assembling a puzzle where each concept serves as a piece that could eventually shape a larger vision.

This stage wasn't about fully developed ideas, those would come later. Instead, I focused on scattered yet meaningful components—the small but powerful ingredients that, when layered together, could create an intelligent and effortless smart home system.
Some of these concepts address automation and AI-driven comfort, others focus on privacy, renter accessibility, energy sustainability, and behavioral engagement. At this stage, nothing is set in stone—everything remains fluid, open-ended, and experimental.

By breaking everything down to these fundamental building blocks, I could begin seeing patterns, gaps, and potential combinations—allowing me to layer solutions rather than forcing them.

With this foundation, I was ready to take the next step: synthesizing these raw ideas into meaningful service experiences and design interventions.

Here's how I approached this phase:

Mapping Out the Key Themes

Before generating concepts, I first clustered my research insights into recurring themes, ensuring my next steps were rooted in actual user needs, behaviors, and technological gaps. The main areas I focused on were:

AI-driven comfort – **How can automation feel effortless instead of intrusive?**

Renters' accessibility – **How can smart home solutions be non-invasive and portable?**

Privacy-first automation – **How can AI optimize without excessive data collection?**

Energy savings that don't sacrifice comfort – **How do we create balance?**

Seamless integration – **How do we eliminate the frustration of disconnected ecosystems?**

Gamification & engagement – **How do we make energy-saving behaviors more intuitive and rewarding?**

Breaking Down the Elements

With those themes in mind, I began listing out micro-elements—small but powerful pieces of functionality that could solve specific pain points.

- **Thermal bubbles** – Personalized heating zones rather than heating an entire home.
- **Hybrid AI Systems** – AI that assists rather than fully taking over.
- **Magnetic Smart Panels** – Stick-on control systems for renters.
- **Context-Aware Lighting** – Adjusting based on time, mood, and routines.
- **AI-powered Sleep & Wake Cycles –** Systems that adapt based on natural rhythms.
- **Predictive Energy Automation** – AI anticipates needs rather than reacting to commands.
- **Decentralized AI Hubs** – Smart home functions without cloud tracking.

This process helped me see smart home design as a set of modular, adaptable parts, rather than a singular, rigid product or service.

Exploring How These Pieces Fit Together

Once I had my raw ingredients, I experimented with how they could combine to create richer user experiences.

- Could AI-driven lighting + personalized energy reports make sustainability more engaging?
- Could non-invasive smart panels + renter-first automation solve the accessibility problem?
- Could decentralized AI + energy efficiency reduce privacy concerns?

This layered approach allowed me to be flexible and iterative, seeing connections without forcing a singular outcome too early.

foundation for my final service and experience design interventions.
With this groundwork in place, I was ready to start bringing these concepts to life.

CONCEPTUALISATION

This section marks the transition from broad conceptual exploration to structured conceptualization, where scattered ideas begin forming cohesive service and product offerings. Instead of jumping straight into polished solutions, I first broke down the essential components—the "ingredients"—that would later be combined into larger systems.

AI & Automation Concepts

Predictive AI that "Learns" Personal Habits

- AI tracks micro-patterns in daily routines (when users wake up, leave home, return, wind down) and adjusts settings before they even interact with the system.
- **Example**: Lights gradually brighten in sync with a user's morning wake-up time.

Self-Healing Automation Loops

- AI monitors how often users override automation (e.g., adjusting thermostats or lights manually) and refines future predictions to reduce annoyance.
- **Example**: If a user always turns the AC back up at 10 PM, AI will stop forcing a lower temperature at night.

AI-Powered Thermal Comfort Zones

- AI detects user location within the home and adjusts heating/cooling only in occupied areas rather than wasting energy on the whole house.
- **Example**: Smart airflow management that directs AC or heat toward active zones instead of running at full power.

AI-Powered Mood Detection for Smart Environments

- Sensors detect stress, fatigue, or relaxation (via smart wearables or voice analysis) and adjust the environment accordingly.
- **Example**: If someone sounds tired, smart lights dim, and the system plays calming ambient sounds.

Smart Home Experience Concepts

Invisible Smart Home Experience

- Smart home interactions should not feel like tech—they should be seamless, intuitive, and effortless.
- **Example**: Users never press buttons or say voice commands; their home just knows what to do.

Passive Sustainability Nudges

- Instead of sending annoying notifications about energy savings, smart systems subtly adjust settings to promote efficiency without disrupting comfort.
- **Example**: If a user forgets to turn off a device, the system slowly dims it instead of abruptly shutting it off.

Multi-Modal Smart Home Controls

- Users can control their home via gestures, voice, app, wearables, or automation—not just one interface.
- **Example**: A swipe in the air dims lights, or a glance at a smart mirror triggers energy reports.

Smart Surfaces Instead of Apps

- The home itself becomes an interface—walls, tables, and mirrors display information and respond to touch or voice.
- **Example**: The bathroom mirror shows today's energy savings as the user gets ready.

Renters & Modularity Concepts

No-Installation Smart Home Kit

- A renter-friendly smart home does not require drilling, wiring, or landlord permission.
- **Example**: All smart tech is portable and stick-on—smart panels, adhesive sensors, magnetic switches.

Subscription-Based Smart Home Experience

- Renters can lease a smart home kit instead of buying expensive devices outright.
- **Example**: A renter pays $10/month for a smart home bundle that moves with them to new apartments.

Adaptive Plug-and-Play AI Sensors

- Clip-on or stick-on sensors that transform normal devices into smart ones.
- **Example**: A clip-on thermostat sensor makes any dumb heater smart by learning usage patterns.

Temporary AI-Powered Smart Windows & Blinds

- Removable smart film that adjusts tint for privacy and insulation without requiring permanent installation.
- **Example**: The film darkens when it senses direct sunlight, reducing AC usage in the summer.

Energy & Sustainability Concepts

Gamified Energy Saving

- Users compete with friends to see who saves the most energy, earning real-world rewards.
- **Example**: A leaderboard compares weekly energy use, and top savers get discounts on local sustainable brands.

Smart Home as a Circular Economy Hub

- The home recommends sustainable practices based on past user behaviors.
- **Example**: The home suggests eco-friendly products when users run out of daily items.

Microgrid-Ready Smart Homes

- Homes that produce, store, and share energy locally rather than relying on a central grid.
- **Example**: A smart home with solar panels + AI storage decides when to store power or share it with neighbors.

AI-Powered Energy Coach

- AI gives context-based suggestions instead of generic tips.
- **Example**: Instead of saying “use less AC,” the system says, “You used 12% less energy this month—want to see how you saved?”

Privacy & Trust Concepts

AI Transparency Dashboard

- Users can see why AI makes decisions (e.g., “Setting AC to 72°F because it’s your preferred sleeping temp”).
- **Example**: AI explains its reasoning so users trust automation instead of feeling controlled.

Privacy-First Smart Home

- AI processes data locally without sending anything to the cloud.
- **Example**: A decentralized AI assistant that doesn’t track user behavior outside the home.

Edge AI for Local Decision-Making

- Smart homes should think on-device, not rely on external servers.
- **Example**: AI runs inside the home itself instead of sending data to Big Tech.

Future Facing Concepts

AIoT (AI + Internet of Things) Sensors

- Microchips that predict user behavior and adjust devices accordingly.
- **Example**: A toothbrush sensor tracks morning routines and signals the coffee machine to start.

Graphene-Based Thermal Materials

- Ultra-thin smart textiles that regulate temperature without heavy HVAC energy usage.
- Example: A couch with built-in self-heating/cooling tech.

Holographic Smart Home Interfaces

- No physical screens—holograms display smart home controls in the air.
- **Example**: A floating holographic thermostat users adjust with gestures.

USER FLOWS

Morning Routine: Waking Up & Starting the Day

User Intent: Wants a smooth, effortless start to the day.
Trigger: AI detects wake-up time based on historical patterns or alarm sync.

Automation:

- Lights gradually brighten (mimicking sunrise).
- Thermostat adjusts to preferred temperature before the user gets out of bed.
- Smart mirror or voice assistant provides a quick status update (weather, schedule, energy usage).
- Coffee machine starts brewing automatically (based on past routines).

User Interaction: Minimal; can adjust settings via voice, touch, or gestures if needed.

Tech & Execution:

- AI Pattern Recognition: Tracks sleep cycles and wake-up trends.
- Smart IoT Devices: Lights, thermostat, appliances sync through a centralized AI hub.
- Touchless Controls: Gesture-based UI for quick manual adjustments.

image credit: chatgpt.com

Leaving Home: Energy Optimization & Security

User Intent: Ensures all devices are off, home is secure, and energy is optimized.
Trigger: AI detects departure via motion tracking, phone geofencing, or manual input.

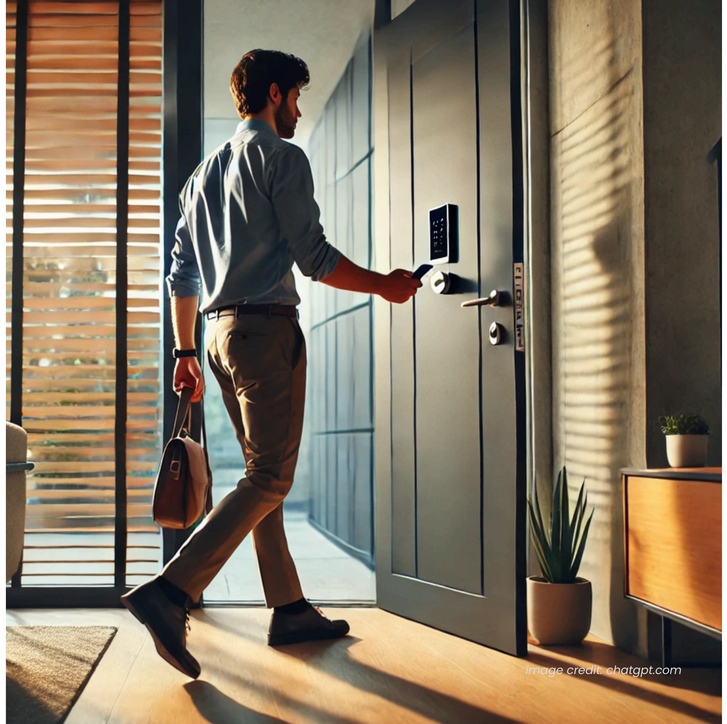
Automation:

- "Away Mode" activates automatically—adjusts thermostat, turns off unnecessary devices, arms security system.
- Smart blinds adjust to conserve energy (e.g., close during hot afternoons).
- Energy usage summary sent to mobile app for user awareness.

- **User Interaction**: Minimal; user can check status via mobile app or smart home dashboard.

Tech & Execution:

- Geofencing & Motion Sensors: Detect user movement to initiate automation.
- Smart Energy Management System (SHEMS): AI optimizes power consumption.
- Cloud-Synced Security: Real-time monitoring via IoT-enabled security systems.



Returning Home: Adaptive Comfort & Smart Adjustments

User Intent: Wants a home that feels welcoming without unnecessary energy waste.
Trigger: AI detects user's proximity via geofencing or door sensors.

Automation:

- Thermostat adjusts to pre-set preferences 10 minutes before arrival.
- Lights turn on gradually in occupied areas (AI tracks user location).
- Ambient settings adjust based on mood detection (e.g., calming lights & music after a stressful workday).

User Interaction: Can modify settings via voice, mobile app, or gesture-based smart surfaces.

Tech & Execution:

- Biometric Mood Detection: AI analyzes voice, facial cues, and wearables.
- Dynamic Lighting & Climate Control: Predictive adjustments based on historical data.
- Smart Locks & Access Control: Secure, hands-free authentication upon arrival.

Evening Routine: Relaxation & Energy Efficiency

User Intent: Wants a stress-free evening while maintaining sustainability.
Trigger: AI recognizes evening patterns (e.g., dimming lights, adjusting HVAC).

Automation:
- Smart lighting shifts to warm, low-intensity mode to promote relaxation.
- Energy report is sent, gamifying sustainable behavior (e.g., "You saved 15% energy today—earn eco-points!").
- Appliances enter low-power standby mode if not actively used.
- AI suggests nighttime settings (e.g., best sleep temperature).

User Interaction: Can check energy savings, adjust settings, or enable "Do Not Disturb" mode via voice or app.

Tech & Execution:
- AI-Driven Energy Reports: Insights delivered in an engaging, gamified manner.
- Circadian Rhythm Smart Lighting: Adjusts based on user's sleep cycle.
- Automated Sleep Optimization: AI ensures optimal air quality, noise control, and temperature for restful sleep.

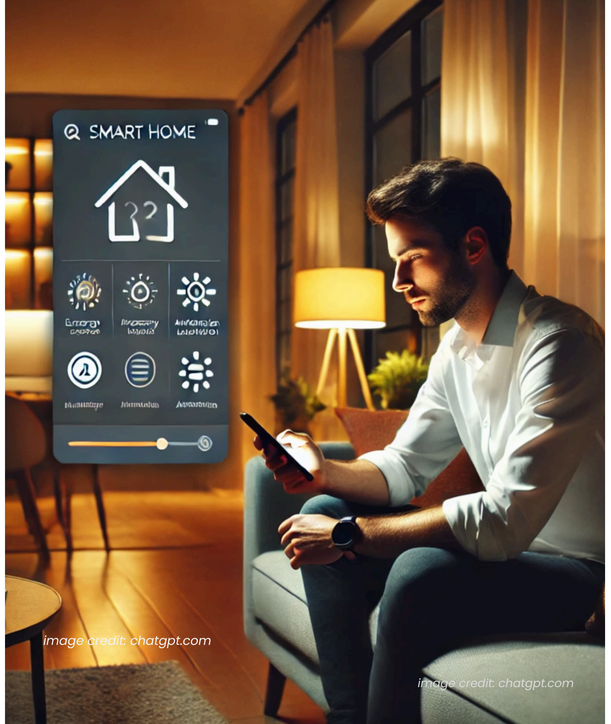


image credit: chatgpt.com

image credit: chatgpt.com

Weekend Mode: Adaptive AI for Flexible Schedules

User Intent: Wants home settings to adjust based on weekend habits rather than rigid weekday patterns.
Trigger: AI detects weekend routines (later wake-ups, more time at home).

Automation:
- Flexible heating/cooling schedules adapt based on real-time occupancy.
- Smart appliances operate on energy-efficient cycles (e.g., laundry runs at optimal grid hours).
- Entertainment & relaxation mode auto-adjusts lighting & music based on activities.

User Interaction: Minimal; user can override via voice, gestures, or app.

Tech & Execution:
- Adaptive AI Scheduling: Learns different routines for weekdays vs. weekends.
- Dynamic Energy Optimization: Adjusts usage based on grid demand and occupancy.
- Smart Entertainment Integration: AI auto-tunes music, lighting, and climate to enhance relaxation.

image credit: chatgpt.com

image credit: chatgpt.com

STAKEHOLDER MAPPING

Figure 5.1 is an elaborate stakeholder map that captures all key players in the smart home ecosystem, ensuring seamless service delivery, adoption, and innovation.

Stakeholder Group	Role in the Smart Home Ecosystem	Key Interests & Influence
Primary Users (Homeowners & Renters)	End-users of smart home technologies. Their feedback drives design and adoption rates.	Comfort, energy savings, privacy, affordability, ease of use, security.
Technology Providers (Smart Home Brands, AI Developers, IoT Manufacturers)	Companies like Nest, Ecobee, Tesla, and Samsung develop AI-driven devices. AI firms refine predictive algorithms for automation.	Product usability, interoperability, AI-driven efficiency, market adoption.
Service Designers & UX Professionals	Craft user-friendly interfaces and seamless experiences in smart home automation.	Intuitive user interaction, personalization, reducing friction in adoption.
Utility Companies & Energy Providers	Provide grid power, integrate renewable energy, and influence smart energy pricing models.	Demand response, sustainable energy optimization, grid efficiency.

Figure 5.1

Stakeholder Group	Role in the Smart Home Ecosystem	Key Interests & Influence
Data Privacy & Security Regulators	Government bodies & privacy advocates ensure ethical AI and secure data management.	Transparency in AI decision-making, protection against surveillance concerns.
Property Managers & Landlords	Control adoption of smart home tech in rental properties. Influence renter accessibility.	Low-maintenance smart home solutions, cost-effective energy management.
Retailers & Distributors	Sell smart home devices & integrate with third-party ecosystems. (e.g., Amazon, Best Buy)	Market expansion, supply chain optimization, product bundling with services.
Renewable Energy & Sustainability Advocates	Support carbon-neutral and energy-efficient home solutions.	Smart grid integration, decentralized energy, microgrid adoption.
Insurance Providers	Provide home insurance incentives for adopting smart security & energy-saving devices.	Risk reduction, lower claims, enhanced home security standards.
Government & Policy Makers	Set energy efficiency regulations, privacy laws, and sustainability incentives.	Smart city initiatives, data protection laws, smart infrastructure investments.
Developers & Real Estate Firms	Incorporate built-in smart home infrastructure into new developments.	Smart property value, low-energy housing solutions, home automation trends.

Figure 5.1

Stakeholder Influence & Collaboration

Figure 5.2 categorizes key players based on their influence and interest in smart home adoption and energy efficiency.

This segmentation ensures that the right stakeholders are engaged at key touchpoints for maximizing impact.

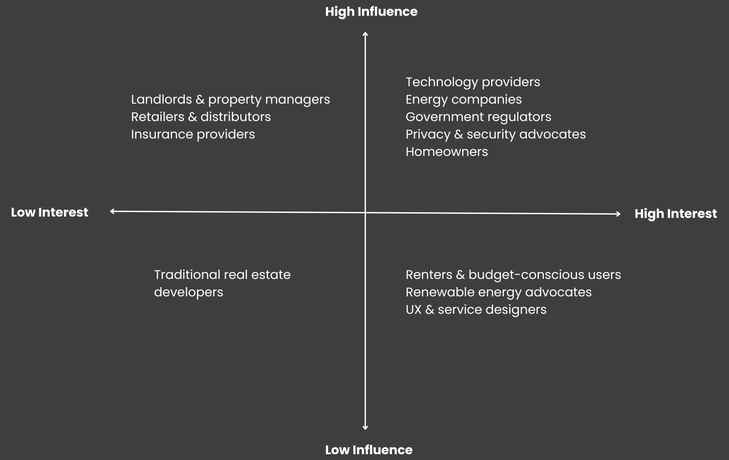


Figure 5.2

IDEATION | **STAKEHOLDER MAPPING**

Key Takeaways from the Stakeholder Map:

Bridging Homeowners & Renters Needs:

- Homeowners drive premium smart home adoption, but renters need modular, flexible solutions.
- Property managers & landlords remain a major barrier—solutions must not require permanent installations.

Government & Utility Partnerships Are Key:

- Smart grid integration and incentives for energy savings can boost adoption.
- Regulations will shape data privacy and AI transparency—solutions should align with emerging standards.

Interoperability & Seamless Experience Matter Most:

- Technology providers, retailers, and UX professionals must collaborate to eliminate friction.
- Unified platforms (cross-device compatibility) will drive long-term engagement by reducing fragmentation.

Next Steps

I will integrate stakeholder-driven insights into my concept refinement, ensuring alignment with both user needs and industry feasibility.

Products that already exists

1. Plug-and-Play Smart Sensors
Eve Door & Window Sensors
- These sensors monitor the status of doors and windows without requiring complex installation, making them ideal for renters.

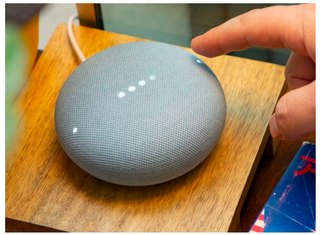
Aqara Motion Sensor
- A compact, wireless motion sensor that can be placed anywhere to detect movement and trigger automation.

2. Matter-Compatible Smart Home Hubs
Aeotec Smart Home Hub
- This hub supports multiple protocols, including Matter, ensuring compatibility across various smart devices.

Samsung SmartThings Station
- A versatile hub that connects and controls a wide range of smart devices, offering Matter support for seamless integration.

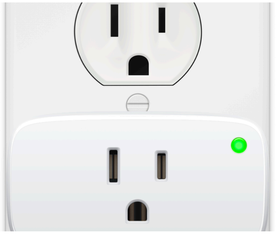
3. **Subscription-Based Smart Home Kits**
Amazon Echo Flex
- A plug-in smart speaker that offers affordable entry into smart home automation, allowing renters to expand their setup over time.

Google Nest Mini
- A compact and budget-friendly smart speaker that serves as a gateway to Google's smart home ecosystem.



4. Decentralized Privacy-Focused AI Devices
Home Assistant SkyConnect
- A USB stick that enables local control of smart devices through Home Assistant, ensuring data remains within the home network.

Eve Energy Smart Plug
- A smart plug that allows local control of connected devices, emphasizing user privacy by processing data on-device.



Products that already exists

5. AI-Driven Comfort & Efficiency Systems
Nest Learning Thermostat

- This thermostat adapts to your schedule, optimizing heating and cooling for comfort and energy efficiency.

Ecobee SmartThermostat with Voice Control

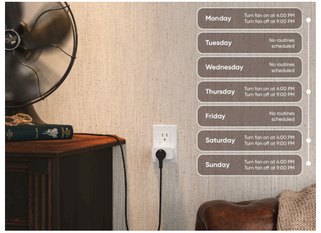
- Equipped with AI capabilities, it learns user preferences to balance comfort and energy savings.

6. Affordable, Renter-Friendly Energy Optimization Devices
Wyze Smart Plug

- An economical option that allows scheduling and remote control of appliances, helping to reduce energy consumption.

TP-Link Kasa Smart Wi-Fi Plug Mini

- A compact smart plug offering energy monitoring features, enabling users to track and manage power usage effectively.



Harnessing Existing Smart Home Technologies into a Unified Renter-Friendly Solution

The current market for smart home products already offers a range of non-invasive, affordable, and highly adaptive solutions that align with your value proposition. However, these devices operate in fragmented ecosystems, often requiring multiple apps, different communication protocols, and manual interventions to work effectively. The opportunity lies in integrating these technologies into a cohesive, renter-friendly, and AI-driven smart home service that prioritizes comfort, energy efficiency, and privacy.

IDEATION

What If?

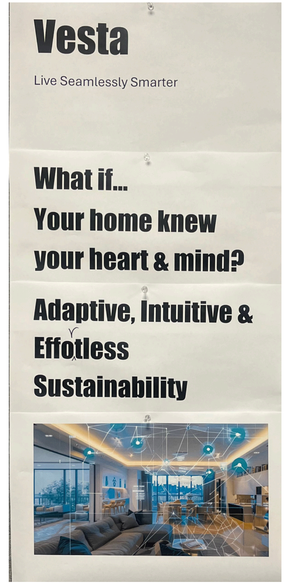
This statement is based on my project insights, framed as an open-ended, thought-provoking question that captures the essence of my work. This statement will be the foundation of my ideation and final design solution.

What if your home knew your body and mind?

Adaptive, intuitive, and effortless sustainability

- No manual adjustments.
- No frustrating overrides.
- No unnecessary energy waste.

Your home, your habits—optimized without compromise.



06. FINAL SOLUTION

Smart home technology has revolutionized the way we interact with our living spaces—enhancing comfort, security, and efficiency.

Yet, for renters and early-adopting homeowners, the smart home industry presents major barriers:

✓ **High installation costs** → Traditional smart home systems require extensive wiring, drilling, and landlord approval.
✓ **Fragmented ecosystems** → Different devices work in isolation, requiring multiple apps and manual adjustments.
✓ **Lack of user trust** → Many users fear over-automation, loss of control, and privacy breaches.

With these challenges in mind, Vesta was created as a renter-friendly, privacy-first, adaptive smart home solution that works without installation barriers. It is designed to seamlessly integrate into any home while prioritizing user comfort, energy efficiency, and hands-free automation.

The development of Vesta was not just about creating another smart home system—it was about rethinking what a smart home should be. My process involved extensive research, iterative prototyping, and a user-first design approach to ensure that Vesta is intuitive, flexible, and impactful.

Introducing Project Name:

Vesta

Which means: *"Warmth, Intelligence, and Energy in Perfect Balance."*

Named after the Roman goddess of home and hearth, symbolizing both comfort and sustainability.

INSIGHTS

Early Research & Insights

I started by researching current smart home trends and analyzing why renters are excluded from smart living experiences. Through surveys, interviews, and competitor analysis, I identified the following key gaps:

- **36**% of U.S. households (44 million renters) lack smart home access due to landlord restrictions.
- High costs prevent adoption—most smart home setups require a **$1,500-$5,000** investment.
- Privacy concerns are a major blocker—**48%** of smart home users disable AI tracking due to security fears.
- Users want automation—but they also want control. **72%** of surveyed users override smart home automation because it doesn't align with their real needs.

These insights shaped my design drivers—principles that guided every decision in Vesta's development.

The Key Principles of Vesta

- Retrofit-Friendly → Works in any home with zero landlord approval.
- Adaptive Sensory System → AI responds to light, temperature, sound, and motion.
- **Privacy-First Automation** → AI runs locally on a secure core hub, eliminating cloud tracking.
- **Seamless & Multi-Modal Control** → Users control their home through wearables, SmartTiles, app, or voice.
- **Energy & Cost Efficiency** → AI reduces energy waste without sacrificing comfort.
- **Holistic Comfort & Mood Customization** → Adjusts lighting, temperature, and sound for well-being.

These and the main insights in **figure 6.1** defined how Vesta would function and shaped my next step: **developing the solution.**

MAIN INSIGHTS FROM SECONDARY & PRIMARY RESEARCH	TAKEAWAY
Renters Can't Fully Adopt Smart Homes	Portability
Users Don't Fully Trust AI Automation	Transparency & User Control
Smart Home Ecosystems Are Too Fragmented	Unified System
Comfort Wins Over Energy Savings	Convenience
Privacy Concerns Limit Adoption	Local AI Processing

Figure 6.1

DESIGN DRIVERS

These design drivers shape Vesta into more than just a smart home product—it's a service-first, adaptive ecosystem that evolves with its users. By focusing on renter accessibility, privacy, effortless automation, and modular scalability, Vesta ensures that any home can feel like the future of smart living.

Adaptability & Seamless Automation

- Vesta should anticipate user needs, not require constant input.
- AI must learn & refine automation based on real user patterns.
- Home environments vary—Vesta should adapt to different spaces and users.

→ **Design Decision:**

- Wearable-based automation that understands movement, biometrics, and user routines.
- SmartTiles for manual adjustments, allowing users to fine-tune automation.
- Geofencing & AI-driven climate control—adjustments happen automatically as users move.

Renter-Friendly, Non-Invasive Installation

- No landlord approval should be required for installation.
- No drilling, wiring, or permanent modifications.
- Must be easy to uninstall and take to a new home.

→ **Design Decision:**

- Magnetic SmartTiles for tap-based home controls (e.g., lighting, security, appliances).
- Wearable device as the primary controller—eliminating the need for installed switches.
- Core Hub manages all automation locally, ensuring seamless connectivity without rewiring.

Privacy-First Smart Home Experience

- AI should process data locally—no cloud storage of personal information.
- Users must retain full control over automation settings.
- Security should be built-in, not an afterthought.

→ **Design Decision:**

- Core Hub runs AI processing locally, so no personal data is sent to cloud servers.
- Wearable encryption ensures private biometric tracking—data stays on the device.
- Users can override automation manually using SmartTiles or the Vesta App.

Energy Efficiency Without Compromising Comfort

- Vesta should save energy without making the home feel inconvenient.
- Users should never feel like they're sacrificing comfort for efficiency.
- Energy-saving should be gamified to encourage long-term behavior change.

→ **Design Decision:**

- Adaptive AI climate control—heats/cools only occupied rooms.
- Real-time energy tracking with personalized AI coaching.
- Gamified sustainability challenges with rewards for reducing energy waste.

Effortless User Interaction

- Users should not have to "manage" a smart home—Vesta should just work.
- Voice, touch, gestures, and automation should provide multiple control options.
- The system should be intuitive even for non-tech-savvy users.

→ **Design Decision:**

- Wearable gesture & voice control for effortless interaction.
- SmartTiles allow quick, tap-based control for instant adjustments.
- Companion app enables deeper customization, but is optional for daily use.

Modular, Scalable, & Future-Proof Design

- Vesta should grow with the user—scalable for both small apartments and larger homes.
- Future smart home tech should integrate seamlessly.
- Users should be able to expand their system over time.

→ **Design Decision:**

- Matter-compatible Core Hub ensures long-term interoperability with new devices.
- Subscription-based model allows users to add more SmartTiles & accessories.
- Modular design—users can customize their system based on home size & needs.

Design Drivers

Emotional & Lifestyle Integration

- Smart home automation should enhance mood & well-being.
- Vesta should recognize when users need relaxation vs. productivity.
- The service should go beyond energy-saving and actively improve daily life.

→ **Design Decision:**

- Mood-based automation—adjusts lighting, music, and temperature for relaxation or focus.
- Biometric feedback from wearables—Vesta can detect stress and adjust home settings accordingly.
- Adaptive morning & night routines—AI helps users wake up and wind down naturally.

"What if your home understood you?"

Imagine a smart home experience that isn't just **reactive—but proactive.**

A system that **adapts to you**, not the other way around.

A living space that **anticipates your needs, optimizes your comfort,** and **reduces energy waste effortlessly**.

Now, what if this was possible without landlord approvals, complex installations, or privacy risks?

Vesta isn't just another smart home product—it's a seamless, renter-friendly, privacy-first smart home service that learns, evolves, and enhances your lifestyle.

DESIGN DECISIONS

Creating a Smart Home That Works for Everyone

The reason for these statements to be my design drivers were to create a smart home service that doesn't just automate life—it understands, adapts, and evolves with you.

No Landlord Approval Needed

Plug-and-play modularity—zero drilling, wiring, or permanent modifications.

Universal Compatibility with Matter

Works seamlessly across Apple, Google, Amazon, and Samsung ecosystems—no device lock-in.

AI That Adapts, Not Dictates

Vesta learns user habits and adjusts automatically, but manual overrides are always available.

Gamified Energy Efficiency

Encourages sustainable habits through personalized energy insights & community challenges.

Privacy-First, Cloud-Free AI

All automation runs locally on the Vesta Core Hub—no data tracking, no third-party access.

Renter & Homeowner Scalability

Designed for renters but powerful enough for homeowners—Vesta grows with you.

WELCOME TO **VESTA**

The future of intuitive, adaptive, & accessible smart living.

Why are Renter's the Target Audience?

80% of renters in the U.S. want smart home technology, but **67%** can't install it due to landlord restrictions.

The demand for intelligent, energy-efficient living is **higher than ever**, yet traditional smart home systems exclude millions of renters—forcing them into outdated, inefficient homes.

Vesta changes that.

The Vesta Plug-and-Play Kit is a hybrid of wearable smart home control and modular smart tiles, giving renters and homeowners flexibility.

Why is this my final solution?

Rethinking Smart Home Accessibility

When designing Vesta, I wanted to address one of the biggest barriers in smart home adoption: accessibility. Traditional smart home setups require complex installations, high upfront costs, and landlord approvals—making them inaccessible to renters and non-tech-savvy homeowners.

I realized that for smart home technology to be truly universal, it needed to be:

- **Effortless to set up** → No drilling, wiring, or professional installation.
- **Portable & Flexible** → Moves with the user, adapting to different home environments.
- **Non-Invasive** → Works within existing home infrastructure without requiring modifications.

That's when I made the key decision: ***Vesta would be a plug-and-play smart home kit.***

Developing the Solution

After defining the problem and key drivers, I needed to create a product that solved these issues in a tangible way.

What Vesta Had to Be

- **Modular & Portable** → No wires, no drilling, no landlord permission.
- I**ntelligent Yet User-Controlled** → Automates seamlessly but allows for manual overrides.
- **Sustainable & Energy-Saving** → AI-optimized efficiency without user effort.

What's Inside the Vesta Kit?

- **Vesta Wearable Smart Controller** (Ring, Bracelet, or Smartwatch)
- **Magnetic SmartTiles** (Renter-Friendly Stick-On Controls) & Smart **Sensors** (Detects light, temperature, sound, and motion)
- **Vesta Core Hub** (AI Brain for Privacy-First Local Automation)
- Vesta Companion App (For overrides, schedules, and preferences)

What's Inside the Vesta Kit?

1 Vesta Wearable Smart Controller (Ring/Bracelet/Clip)

AI-Powered Home Control → Adjusts lighting, climate, and security automatically using biometric data (heart rate, movement, skin temp).

Gesture & Haptic Control → Users can wave or tap to control devices.

UWB Room Detection → Knows which room you're in and adjusts settings accordingly.

Privacy-First Local AI → Processes user data without cloud tracking.

What's Inside the Vesta Kit?

2 Modular SmartTiles (Renter-Friendly Magnetic Controls)

- **Stick-on, Tap-to-Use Smart Controls** → No drilling or landlord approval required.
- **Thread & Zigbee-Powered Smart Panels** → Controls lighting, security, and appliances.
- **NFC One-Tap Commands** → Assign functions like "Eco Mode" or "Away Mode" with a single tap.
- **E-Paper Display Option** → Energy-efficient screen for minimal power use.
- **Battery-Powered & Solar Rechargeable** → No need for wires or outlets.

What's Inside the Vesta Kit?

3 Vesta Core Hub (Matter-Compatible AI Brain)

- **Unified Control for All Devices** → Syncs Vesta wearables & SmartTiles with existing smart home devices.
- **AI-Driven Comfort Adjustments** → Learns preferences and predicts energy-efficient settings.
- **Matter & Bluetooth LE Integration** → Supports Apple, Google, Amazon, Samsung devices.
- **Privacy-Focused Local AI** → Smart home automation without cloud reliance.

What's Inside the Vesta Kit?

4 Vesta Companion App

- **Hybrid AI & Manual Control** → Users can override settings via app, voice, or wearables.
- **Sustainability Dashboard** → Real-time energy tracking, carbon footprint, and savings.
- **Gamified Energy Challenges** → Compete with friends or community to reduce waste.
- **Personalized AI Energy Coaching** → Context-aware energy suggestions.

FUNCTIONALITY

Vesta operates across four key domains, ensuring an optimized smart home experience for renters & homeowners

1 Adaptive Comfort & Climate Control

Smart Temperature – AI auto-adjusts heating/cooling based on user habits & room sensors.

Lighting Automation – Circadian-based light shifts, gesture & voice control, presence detection.

Air Quality Monitoring – Auto-adjusts humidity, CO_2 & air purifiers.

Sleep Optimization – Wearable detects bedtime, adjusts temp, lights, and sounds.

2 Energy & Sustainability Management

AI-Driven Energy Savings – Eco Mode, Away Mode, real-time usage insights.

Gamified Sustainability – Earn points for reducing energy & unplugging devices.

Smart Water Tracking – Monitors usage, detects leaks, sends alerts.

Appliance Automation – Optimized scheduling for efficiency.

3 Security & Privacy Protection

Smart Locks & Security – Auto-lock/unlock, geofencing, camera integration.

Privacy-First AI – Local processing, encrypted device communication.

Emergency Features – Wearable detects stress, panic button-enabled SmartTiles.

4 Seamless User Interaction & Automation

Wearable Control – Adjusts home settings via biometrics & gestures.

SmartTiles – Modular, renter-friendly tap-to-control panels.

Personalized AI Learning – Adapts automation to user habits.

Multi-Mode Interaction – Control via wearables, SmartTiles, app, or voice.

Figure 6.2

FINAL DESIGN | **FUNCTIONALITY**

Core Functional Areas Vesta Covers (Figure 6.2)

Adaptive Comfort & Climate Control

Objective: Ensure ideal temperature, lighting, and air quality based on user preferences & real-time conditions.

Temperature Control
- AI-driven smart thermostat automation based on user patterns.
- Localized heating/cooling using room detection sensors.
- Wearable-triggered adjustments (e.g., detects body temp, adjusts AC).

Lighting Automation
- Circadian-based light adjustments (gradually shifts throughout the day).
- Gesture & voice control for quick brightness/tone changes.
- Presence-based lighting (turns on/off when entering/exiting rooms).

Air Quality & Ventilation
- Monitors humidity, CO2, air pollutants & suggests adjustments.
- Smart air purifiers activate automatically if poor air quality detected.

Sleep & Relaxation Mode
- Wearable detects bedtime routine & adjusts environment accordingly.
- Temperature cools, lights dim, sounds adjust for optimal sleep.

Energy & Sustainability Management

Objective: Reduce energy waste, automate eco-friendly actions, and provide real-time sustainability insights.

Energy Optimization
- AI auto-adjusts devices to reduce unnecessary consumption.
- Smart energy-saving presets (Eco Mode, Away Mode).

Sustainability Tracking & Gamification
- Real-time energy reports show consumption trends & savings.
- User earns points for eco-friendly behaviors (reducing usage, unplugging devices).

Water Usage Monitoring
- SmartTiles track shower & appliance water usage.
- Sends alerts for excessive use or water leaks.

Smart Appliance Automation
- Syncs with appliances (e.g., runs dishwasher during off-peak hours).

Security & Privacy Protection

Objective: Ensure safe, private, and encrypted home automation.

Home Security
- Smart lock automation (wearable detects presence & auto-locks/unlocks).
- Security camera integration (view footage via app).
- Geofencing activates Away Mode for enhanced security.

Data Privacy & AI Transparency
- Local AI processing (no cloud tracking).
- User-controlled privacy toggles (disable tracking anytime).
- Encryption-first communication between devices.

Emergency & Alerts
- Wearable detects stress levels & can alert emergency contacts.
- SmartTiles act as emergency panic buttons.

Seamless User Interaction & Automation

Objective: Ensure a frictionless smart home experience with adaptive AI & intuitive control methods.

Wearable Automation (Ring/Bracelet/Clip)
- Detects biometric cues to automate settings.
- Allows gesture-based control (e.g., wave to turn off lights).

SmartTiles (Modular Magnetic Controls)
- Stick-on panels for manual overrides & quick controls.
- One-tap NFC buttons for instant mode switching (Eco, Sleep, Security).

AI Learning & Personalization
- Learns user habits over time & adjusts automation accordingly.
- Provides real-time recommendations via the Vesta Companion App.

Multi-Modal Interaction
- Control via wearables, SmartTiles, app, or voice.
- Offline mode ensures functionality even without WiFi.

Vesta focuses on five key aspects of a home environment:

1

Lighting Control

Adaptive brightness.
Circadian lighting.
Allow Manual Overrides.

2

Temperature & Airflow Management

Tracking with wearables & biometrics.
Smart climate zoning.
Portable SmartTiles

3

Energy Optimization

Smart scheduling based on energy demands.
Real-time energy usage.
AI-coached energy savings.

4

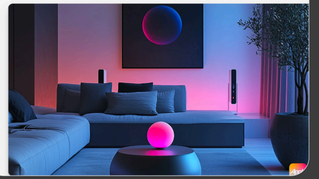
Security & Privacy

Voice & gesture-based locks.
Geofencing activates ‘Away Mode’.
Core Hub ensures private, local AI processing.

5

Mood & Ambience Customization

Adaptive music, lighting, and fragrance based on stress levels.
One-tap relaxation modes.



Vesta was designed with a human-first mindset, ensuring that smart home automation is not just about convenience but seamlessly integrates into daily life while maintaining privacy, adaptability, and ease of use. Through extensive research, insight gathering, and system mapping, five key aspects of home environments were identified as essential to a renter-friendly, truly intelligent smart home experience.

This framework shaped every aspect of Vesta’s design, ensuring that its modular components—the Wearable Smart Controller, SmartTiles, Core Hub, and Companion App—work in harmony to create an intuitive, renter-friendly smart home experience. Every feature was meticulously refined through user research, system mapping, and iteration, leading to a seamless, personalized, and future-ready home automation solution.

FINAL DESIGN | **FUNCTIONALITY**

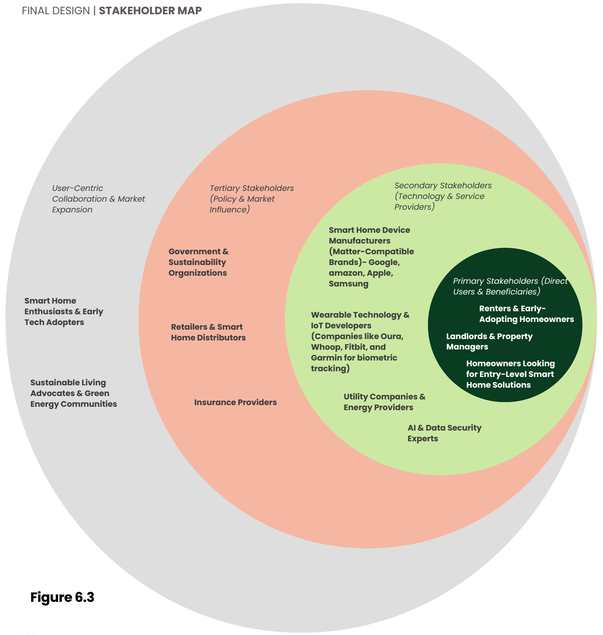


Figure 6.3

STAKEHOLDER MAP

This stakeholder map categorizes key players involved in the adoption, execution, and impact of Vesta—a renter-friendly, AI-powered smart home system.

Primary Stakeholders (Direct Users & Beneficiaries)

1. Renters & Early-Adopting Homeowners (Target Audience)
   - Seeking non-invasive smart home solutions with affordability & flexibility
   - Interested in energy savings, automation, and seamless user experience
2. Landlords & Property Managers
   - May be hesitant but could see value in energy-efficient properties
   - Benefit from increased rental appeal & sustainability incentives
3. Homeowners Looking for Entry-Level Smart Home Solutions
   - Not ready for full wired automation but want modular control
   - Concerned about privacy & integration with existing devices

Secondary Stakeholders (Technology & Service Providers)

1. Smart Home Device Manufacturers (Matter-Compatible Brands)
   - Google, Apple, Amazon, Samsung (Matter & Thread-enabled device providers)
   - Can partner with Vesta to expand plug-and-play adoption.

2. Wearable Technology & IoT Developers
   - Companies like Oura, Whoop, Fitbit, and Garmin for biometric tracking
   - Could collaborate for AI-based automation & gesture control
3. Utility Companies & Energy Providers
   - Smart home energy solutions align with sustainability incentives
   - May offer rebates for renters & homeowners using Vesta's optimization
4. AI & Data Security Experts
   - Ensuring privacy-first local AI automation (no cloud storage required)
   - Developing Edge AI for home automation without invasive tracking.

Tertiary Stakeholders (Policy & Market Influence)

1. Government & Sustainability Organizations
   - Energy-efficient smart homes contribute to green building standards
   - Potential subsidies for home energy optimization technologies
2. Retailers & Smart Home Distributors
   - Tech stores (Best Buy, Home Depot, Amazon) selling plug-and-play smart home kits
   - Subscription-based retailers offering Vesta as a service
3. Insurance Providers

- Home insurance companies may incentivize smart security & automation
- Potential for lower premiums for renters & homeowners using Vesta.

User-Centric Collaboration & Market Expansion

1. Smart Home Enthusiasts & Early Tech Adopters

- Driving word-of-mouth adoption through tech communities & social influence
- Engaging in gamified sustainability & energy challenges

2. Sustainable Living Advocates & Green Energy Communities

- Promoting renter-friendly sustainability through non-invasive solutions
- Encouraging participation in local and national energy-saving initiatives

How Stakeholders Interact

Renters & Homeowners → Direct users benefiting from plug-and-play smart home convenience.

Smart Home Device Brands & Utility Companies → Provide Matter-compatible devices & energy incentives for adoption.

Retailers & Subscription-Based Platforms → Distribute & promote the Vesta Smart Home Kit to consumers.

Government & Sustainability Organizations → Offer potential tax credits & sustainability rebates.

Wearable Tech Companies & AI Developers → Advance biometric-based home automation for comfort & efficiency.

HOW DOES IT WORK?
SYSTEM MAPPING

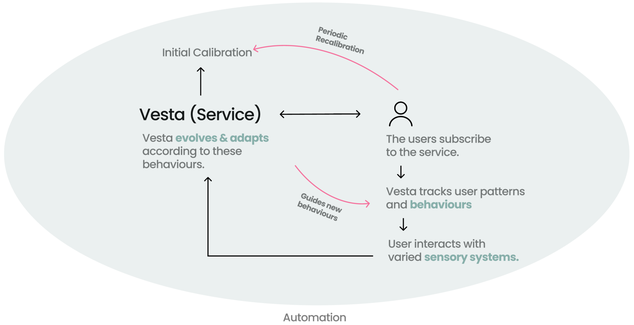


Figure 6.4

At its core, Vesta functions as a continuous learning system that calibrates itself to user habits, environmental conditions, and real-time interactions through wearable technology, modular SmartTiles, and a privacy-first AI hub. The system does not require permanent modifications, making it ideal for renters and flexible home environments.

Through initial calibration, periodic recalibration, and automation, Vesta bridges the gap between human behavior and smart home automation, ensuring that the system is always aligned with user preferences and evolving needs.

Figure 6.4 represents the feedback loop of how Vesta continuously adapts and improves:

1. **Users subscribe to Vesta** → They receive a plug-and-play kit (wearable, SmartTiles, and AI hub).
2. **Vesta tracks user patterns & behaviors** → Sensors & AI analyze environmental conditions, movement, and interactions.
3. **Users interact with varied sensory systems** → Vesta learns from SmartTile taps, voice commands, biometrics, and geofencing.
4. **Vesta evolves & adapts** → Automation adjusts lighting, climate, energy settings, and security based on usage.
5. **Guiding New Behaviors** → Vesta suggests eco-friendly optimizations, enhancing both user experience and energy efficiency.
6. **Periodic Recalibration** → The system refines automation over time to align with evolving needs.

How Does Vesta Scale Across Different Home Types?

For Renters

Plug-and-Play Simplicity

No drilling or landlord approval required (wearable + stick-on SmartTiles).

Subscription model allows upgrades & returns based on lease duration.

Users don't lose their smart home investment when they move—Vesta moves with them.

For Homeowners

Expanded System Integration

Connects with existing smart home setups (Matter-compatible hub).

Optional add-ons available (e.g., solar energy tracking, advanced automation).

Scalability Plan

Tiered Offerings for Different Users

Vesta is designed for both renters and homeowners, but their use cases differ.

Feature	Renters	Homeowners
Wearable Automation	✓	✓
SmartTiles (non-invasive control)	✓	✓
Core Hub (local AI processing)	✓	✓
Permanent installations	×	✓
Expanded automation	×	✓

USER JOURNEY

Jake's User Journey

Waking Up

Adaptive Morning Routine

Trigger: Vesta detects user waking up (biometric wearables, movement in bed, scheduled wake-up time).

System Response:

- Lights gradually brighten to mimic sunrise.
- Thermostat adjusts to pre-set morning preferences.
- SmartTiles display the day's weather & energy stats.
- Coffee machine starts brewing (if connected).
- Soft background music or news briefing begins (if enabled).

Leaving Home

Energy Optimization & Security

Trigger: User moves toward the door (wearable detects motion, door sensors activate, SmartTile tap, or geofencing).

System Response:

- "Away Mode" activates → Non-essential devices turn off.
- Thermostat shifts to energy-saving mode.
- Lights automatically shut off.
- Smart security system arms itself.
- App notification confirms all settings & savings.

USER JOURNEY

Returning Home

Personalized Welcome Back

Trigger: User approaches home (wearable geofencing, door sensors detect proximity).

System Response:

- Thermostat pre-adjusts to ideal temperature before arrival.
- Lights turn on softly (if after sunset).
- Music or preferred ambiance setting activates.
- Smart lock auto-unlocks for hands-free entry.
- Air quality sensor checks & adjusts purification if needed.

Night Routine

Winding Down for Sleep

Trigger: User slows down activity (biometric cues, SmartTile tap, voice command).

System Response:

- Lights dim gradually to signal sleep time.
- Thermostat shifts to sleep mode.
- Wearable tracks heart rate & suggests optimal sleep conditions.
- Appliances power down into energy-saving mode.
- Security system arms automatically.

Sudden temperature change, excessive energy use, or inactivity.

- Smart climate control auto-adjusts based on user location in home.
- SmartTiles nudge user (e.g., "Shutting off unused AC—Swipe to override").
- Wearable vibrates gently for notifications instead of intrusive alerts.

User completes a sustainable action

- App shows real-time energy savings & CO2 reduction.
- User earns points for sustained energy efficiency.
- Friendly competition ranks savings among household/community.

User activates privacy mode

- AI switches to local-only processing (no data sent to cloud).
- Live tracking & monitoring disabled for complete privacy.
- Security settings confirm end-to-end encryption.

Vesta offers an effortless and renter-friendly smart home experience by integrating wearable automation, modular smart tiles, and an AI-powered hub—all designed for privacy-first, adaptive comfort, and energy efficiency. Here's a journey of how it functions:

Setup & Installation – Seamless, Plug-and-Play Experienc

User: A renter in an urban apartment who wants an easy-to-install smart home system.

Step 1: Unbox & Activate

- User unpacks the Vesta Kit, which includes:
  - Vesta Core Hub (the AI brain)
  - Wearable Smart Controller (smart ring or bracelet)
  - 3 Magnetic SmartTiles
  - Quick-start guide
- The system is plug-and-play—no drilling, wiring, or landlord approval needed.

Step 2: Place SmartTiles & Wear the Controller

- User sticks SmartTiles near frequently used areas (e.g., front door, bedroom, kitchen).
- Wears Smart Ring/Bracelet, which syncs with Vesta Core Hub automatically.
- The system self-configures in minutes, recognizing user preferences via the Vesta Companion App.

Step 3: Connect Devices

- Vesta Core Hub automatically detects and syncs with existing smart home devices (lights, thermostats, security systems).
- Matter & Bluetooth LE integration ensures compatibility across brands (Apple, Google, Amazon, Samsung).
- AI begins learning habits without cloud reliance—100% local processing for privacy.

Technology & Service System – What Powers Vesta?

Component	How It Works	Technology Used
Wearable Smart Controller	Tracks biometrics & automates comfort settings. Allows gesture/tap-based manual overrides.	**Biometric AI, Ultra-Wideband (UWB) tracking, Haptic feedback, Bluetooth LE**
Modular SmartTiles	Tap-to-activate smart home controls for renters. Can assign NFC-based commands like "Away Mode."	**Thread & Zigbee, NFC, Battery & Solar-powered, E-Paper Display (optional)**
Vesta Core Hub	AI brain that syncs all devices, ensuring privacy-first smart home control.	**Matter-compatible AI, Bluetooth LE, Local AI Processing (No cloud tracking)**
Vesta Companion App	Allows hybrid AI/manual control, energy tracking, and gamified sustainability challenges.	**AI-driven user insights, Gamification, Data visualization**

Vesta is built for mobility, ensuring that users don't lose their smart home experience when they move or upgrade their home.

Seamless Moving Process:
- Users pack up their kit & reinstall it in their new home—no rewiring needed.
- AI remaps the home layout and updates automation in a new environment.

Easy Upgrades:
- Subscription users can upgrade devices (new wearables, extra SmartTiles).
- Modular components mean users can expand or reduce their setup without replacing the entire system.

Transferable Preferences:
- User settings are stored locally on the Core Hub, so automation resumes without reconfiguration.
- AI adjusts to new home conditions (e.g., different light exposure, room sizes).

Outcome: Users don't lose their smart home investment when they move—Vesta moves with them.

Vesta offers a user-friendly onboarding & support system.

1

Step-by-Step Onboarding (First-Time Setup)

Guided activation through the Vesta Companion App.

Wearables & SmartTiles auto-pair with the Core Hub upon unboxing.

AI gradually learns behaviors instead of enforcing instant automation.

2

In-App Assistance & AI Support

24/7 AI-driven chatbot for instant troubleshooting.

Video tutorials & interactive guides for manual adjustments.

3

Subscription & Maintenance Support

Subscription users get automated replacement or upgrade options.

Hardware diagnostics alert users to low battery, wear & tear, or system updates.

4

Community & Gamification Engagement

Users can share energy-saving insights & compete in gamified sustainability challenges.

AI tracks long-term habits & suggests eco-friendly adjustments.

Vesta ensures effortless onboarding, minimal troubleshooting, and continuous engagement, making smart home automation easy for all users.

VIDEO PITCH

The Vesta video serves as a concise, engaging narrative that communicates the vision, functionality, and impact of the Vesta smart home system. Designed in iMovie with video clips generated on Sora, it highlights the user experience rather than the technology itself. The video portrays how Vesta seamlessly integrates into daily life, adapting and automating home environments effortlessly.

Video Link

07. IMPACT

BEHAVIOUR CHANGE

Vesta is not an one-size-fits-all system—it adapts to different home environments and user needs while maintaining privacy and ease of use.

The Vesta video serves as a concise, engaging narrative that communicates the vision, functionality, and impact of the Vesta smart home system. Designed in iMovie with video clips generated on Sora, it highlights the user experience rather than the technology itself. The video portrays how Vesta seamlessly integrates into daily life, adapting and automating home environments effortlessly.

How Vesta Adapts Over Time

Vesta continuously learns from the user's daily patterns and adjusts settings accordingly.

Tracking & Data Collection

Wearable monitors

Heart Rate | Movement | Stress Signals

SmartTiles detect

Temperature | Room Occupancy | Manual Overrides.

How Vesta Adapts Over Time

AI Processing & Automation

Core Hub analyzes trends in behavior.

If the user manually overrides settings, AI refines its automation.

Customization & Adaptation

AI provides suggestions via app or voice interface

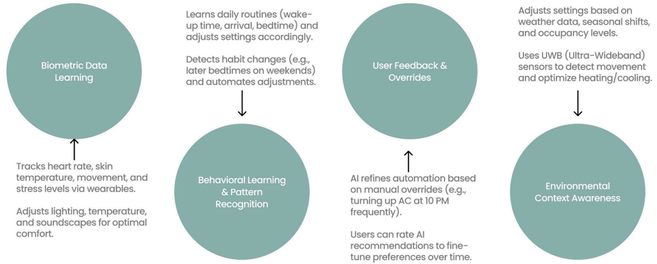
(e.g., "Would you like to preheat the bedroom before bed?")

User feedback refines automation over time.

Energy coaching gamifies sustainability and rewards eco-friendly habits.

Over time, Vesta becomes an intelligent home assistant that minimizes user input while maximizing comfort, efficiency, and sustainability.

How Does Vesta Learn?



Vesta operates through proactive and reactive triggers, ensuring it adapts to user preferences while minimizing manual input.

Proactive Triggers (Predictive AI-Based Automation):

Biometric Data

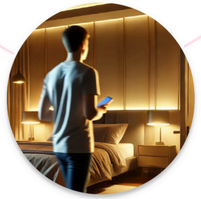
If the user's heart rate is elevated after work, Vesta lowers ambient lighting and plays calming sounds.

Detects heart rate, stress levels, and temperature to adjust home settings accordingly.

UWB Movement Detection

Walking into the bedroom triggers warm lighting and pre-bedtime temperature adjustments.

Identifies user location within the home and adjusts environment settings in real time.



Daily Routine Learning

AI detects wake-up time trends and gradually brightens lights 10 minutes before the alarm.

Vesta recognizes recurring patterns and pre-adjusts home settings before the user interacts.

Geofencing & Proximity Awareness

When the user leaves home, "Away Mode" activates, optimizing energy usage.

Uses phone location and wearables to detect when the user is arriving or leaving.

Reactive Triggers (User-Controlled Adjustments)

Gesture-Based Commands

A wrist flick adjusts lighting intensity, a tap on SmartTile toggles Eco Mode.

Users can wave their hand, double-tap their wearable, or interact with SmartTiles to manually adjust settings.

Voice Commands (Privacy-First AI)

Saying "I'm cold" adjusts heating without accessing an app.

Users can enable or override automation hands-free.

SmartTile NFC Controls

A tap on the SmartTile dims all lights, locks doors, and activates sleep mode.

Users can tap preset commands (e.g., "Night Mode," "Relax Mode") to trigger customized settings.

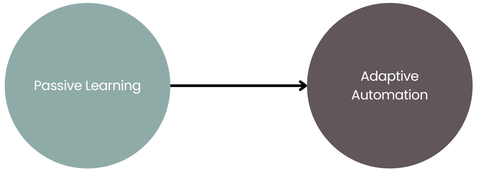
Companion App Overrides

User disables a specific automation (e.g., disabling auto-blinds on weekends).

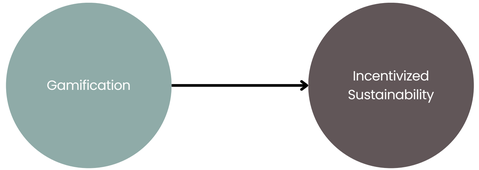
The app provides manual control and real-time automation feedback.

Driving Behaviour Change

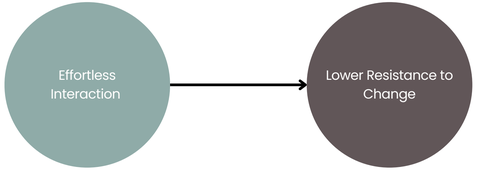
Vesta isn't just a smart home system—it's designed to subtly shift user habits toward energy efficiency, comfort, and convenience without requiring effort or frustration.



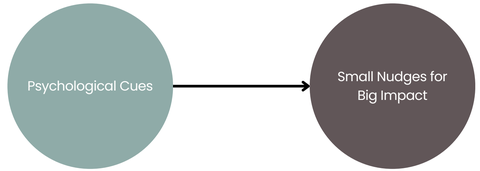
Vesta observes user patterns (wake-up time, preferred lighting, climate settings).
Over time, it automates adjustments—gently reinforcing energy-efficient behaviors without disrupting comfort.
Example: If a user always lowers the thermostat before bed, Vesta preemptively adjusts it.



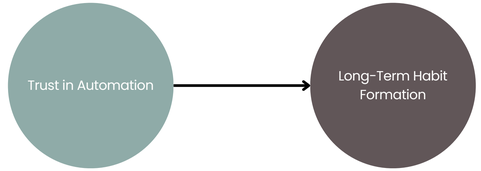
Users see their energy savings in real-time through the Sustainability Dashboard.
Challenges & Rewards encourage participation (e.g., "Reduce energy by 10% this week & earn perks.")
Example: A renter sees they're saving $15/month from optimized AC use—reinforcing the behavior.



Gesture + Voice + Wearable Controls eliminate friction—users don't need to manually adjust devices.
Tactile SmartTiles provide instant, intuitive control, making it easier to form habits.
Example: Instead of opening an app, a simple tap on a tile activates "Eco Mode" before leaving home.



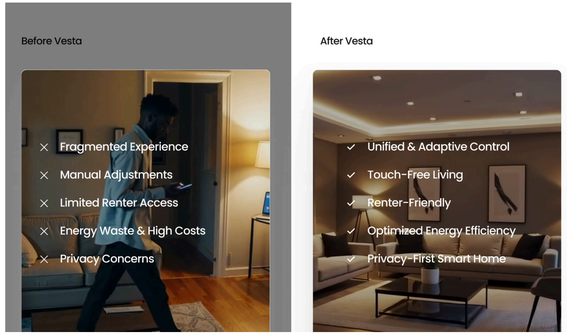
Sustainability tips & real-time impact tracking create awareness without nagging.
Example: Instead of a notification saying, "You left the AC on," Vesta says, "Turning off AC now saves the same energy as skipping a 10-minute shower."



Users can override AI anytime, which builds trust and encourages gradual adoption.
Over time, as users see consistent benefits (lower bills, seamless automation), they lean into automation more.

The Impact

- Reduces energy waste without forcing behavior changes.
- Turns sustainability into a natural, engaging habit.
- Creates a smart home that evolves with its users—without them even realizing it.



IMPACT & TRANSFORMATION

Market Reach & Adoption Potential

Target Audience Size:
Renters in the U.S.: ~36% of U.S. households (~44 million renter households).
Early-Adopting Homeowners: ~20% of homeowners (~16 million households) already use smart home devices.
Potential Market Size: ~60 million households interested in plug-and-play smart home solutions.

Adoption Rate Projection:
Short-Term (1-3 years): 10-15% adoption within the tech-savvy rental and early-adopter homeowner demographic.
Long-Term (5-10 years): As smart home tech becomes standard, adoption could scale to 40-50% of the target audience.

Key Drivers of Adoption:
✓ Ease of Use & Renter Accessibility → No installation, landlord approval, or high costs.
✓ AI-Driven Energy Savings → Clear financial benefits from reduced utility bills.
✓ Privacy-First Approach → Addresses major smart home adoption barriers.

Economic & Financial Impact

Reduced Utility Costs for Renters & Homeowners
- Smart home automation reduces energy waste by up to 30%.
- Average U.S. energy bill savings: ~$300-$500 annually per household.
- Cumulative Savings Across Target Audience:
  - If 5 million users adopt Vesta → $1.5 to $2.5 billion in annual energy savings.
  - If 20 million users adopt Vesta → $6 to $10 billion saved per year.

Incentivized Sustainability & Green Energy Programs
- Potential for utility partnerships offering discounts to Vesta users.
- State & federal incentives could subsidize AI-powered energy efficiency solutions.

Lower Cost Barrier for Smart Home Adoption
- Existing smart home systems require $1,500 - $5,000 upfront costs.
- Vesta's subscription-based model (~$10-$30/month) makes smart living affordable & accessible to renters and new homeowners.

Environmental & Sustainability Impact

Lower Household Energy Consumption
- Projected Reduction: 20-30% per household.
- Impact if adopted by 10 million households:
  - Energy savings → Equivalent to shutting down 100+ fossil fuel power plants annually.
  - CO_2 Reduction → Saves 50-75 million metric tons of CO_2 per year (equivalent to taking 15 million cars off the road).

Shift Towards Circular Economy in Smart Homes
- Renter-friendly smart home tech reduces e-waste by focusing on modular, upgradeable, and repairable components.
- Lower resource consumption due to adaptive energy efficiency & real-time smart grid integration.

60 million U.S. households are potential adopters of plug-and-play smart home solutions.

$10-$30/month subscription model makes smart home automation **10x** more affordable than traditional systems.

Smart automation cuts energy waste by up to **30%.**

Potential annual energy bill savings are **$300-$500** per household.

20-30% reduction in household energy consumption.

10 million users = equivalent to shutting down **100+ fossil fuel** power plants annually.

Behavioral & Lifestyle Shifts

More Energy-Conscious Living

- Gamification & AI energy coaching → Encourages better energy habits among renters & homeowners.
- Users actively track their impact via the Sustainability Dashboard (daily, monthly, annual energy insights).

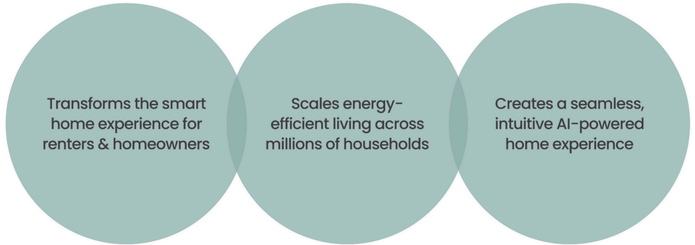
Higher Trust & Engagement with Smart Home Automation

- Current smart home adoption barriers include privacy concerns & lack of seamless integration.
- Vesta's privacy-first AI & Matter integration → Boosts trust and usability.

New Smart Home Usage Patterns for Renters

- Renters currently have limited access to smart home automation.
- Vesta provides full access without landlord intervention, encouraging a new wave of adoption in rental properties.

Why Vesta is the Future of Smart Home Living



THE LONG-TERM VISION OF VESTA

Transforms the smart home experience for renters & homeowners – eliminating cost, installation, and usability barriers.

Scales energy-efficient living across millions of households → driving sustainability at a national level.

Shifts smart home adoption trends, closing the gap between energy-conscious renters & homeowners.

Creates a seamless, intuitive AI-powered home experience → built on privacy, affordability, and ease of use.

If executed successfully, Vesta has the potential to redefine the future of smart living, making energy-efficient, AI-driven automation the standard for U.S. homes.

CONCLUSION

Bringing Vesta to Life: From Research to Innovation

Vesta wasn't just an idea—it was a response to a real, unaddressed gap in smart home technology. My journey in developing this concept started with a fundamental question:

How can smart home technology be truly adaptive, renter-friendly, and privacy-first while maintaining an effortless user experience?

Through extensive secondary research, I analyzed the state of smart home adoption, the barriers to entry, and the gaps in existing solutions. The research showed that while smart home devices were evolving, they were often complex, intrusive, or required high upfront costs, making them inaccessible to renters and casual adopters. Additionally, concerns over privacy, automation control, and sustainability remained key deterrents for widespread adoption.

Research & Discovery: Understanding the User Needs

To move beyond assumptions, I conducted primary research, including user interviews, surveys, and behavioral studies. I focused on:

- Renters & Early-Adopting Homeowners → What were their main pain points with smart home integration?
- Smart Home Skeptics → What were the key reasons they hesitated to adopt smart home technology?
- Sustainability-Conscious Users → What role could automation play in encouraging eco-friendly behaviors?

The affinitization process helped distill these findings into key insights:

- Renters lacked control over their home infrastructure, preventing them from installing wired smart home systems.
- Users wanted automation, but not at the cost of control—trust in AI was low, and over-automation was a major concern.

- Smart home adoption required simplicity—users wanted plug-and-play solutions without complex setups.
- Sustainability incentives were ineffective—users needed tangible, real-time feedback on energy savings to engage with eco-friendly choices.
- Privacy concerns were a major adoption barrier—cloud-based automation felt intrusive, requiring a local-processing solution.

Ideation & Service Design Thinking

Rather than focusing on a single device, I approached this challenge as a service design problem:

What if smart home automation wasn't something you installed, but something that adapted to your lifestyle seamlessly?

The result? A plug-and-play, modular smart home kit that evolves with the user—requiring no installation, no landlord approval, and no dependence on cloud data.

Designing Vesta: My Thought Process

I made several critical design decisions to ensure Vesta was not just another smart home gadget, but an actual shift in how users interact with their living spaces.

- Wearable-Driven Smart Home Control → Instead of relying on static control panels, Vesta introduced gesture-based, biometric wearables (ring, bracelet, clip) that intelligently adjusted the home environment.
- Magnetic SmartTiles for Intuitive Control → To ensure renters had physical control, modular SmartTiles acted as tappable, renter-friendly automation hubs—providing quick manual overrides when needed.
- AI That Learns & Adapts, Not Just Responds → Unlike conventional automation, Vesta's AI didn't just follow preset rules—it learned user behaviors, evolving over time to optimize energy use, comfort, and security.
- Privacy-First, No Cloud Dependence → One of my biggest priorities was ensuring Vesta processed data locally via its Core Hub, ensuring full user control over automation and security.
- Gamified Sustainability Engagement → Vesta didn't just track energy use—it translated savings into tangible insights, making eco-friendly habits engaging and rewarding.

IMPACT | **CONCLUSION**

Final Outcome: The Vesta Plug-and-Play Kit

After several iterations, refinements, and critiques, the final solution became Vesta—a renter-friendly, adaptive, and privacy-first smart home kit that provides:

- Vesta Wearable Smart Controller → Gesture & biometric-driven home control via a ring, bracelet, or clip-on.
- Modular SmartTiles → Portable, tap-to-use smart controls for renters, requiring no installation.
- Vesta Core Hub → Matter-compatible AI brain that ensures automation works locally without cloud tracking.
- Vesta Companion App → A hybrid AI & manual control system that lets users override automation, track energy savings, and engage with their smart home effortlessly.

The Future of Smart Living with Vesta

Vesta is more than a smart home kit—it represents a shift in the smart home paradigm. It proves that automation doesn't have to be intrusive, complex, or rigid—it can be adaptive, seamless, and accessible to everyone.

Through this process, I learned:

- ***The best smart home solutions are the ones that disappear into the background.***
- ***Users want control, but they also want things to "just work" when they need them.***
- ***Sustainability must be incentivized in a way that is engaging, not just informative.***
- ***A truly user-centered design considers different living scenarios—not just homeowners, but renters and transient users.***

This project was a deep dive into human behavior, automation ethics, and the future of smart living—and Vesta is my answer to a smarter, more adaptive, and renter-friendly way of interacting with our homes.

Vesta isn't just a smart home system—it's a home that evolves with you.

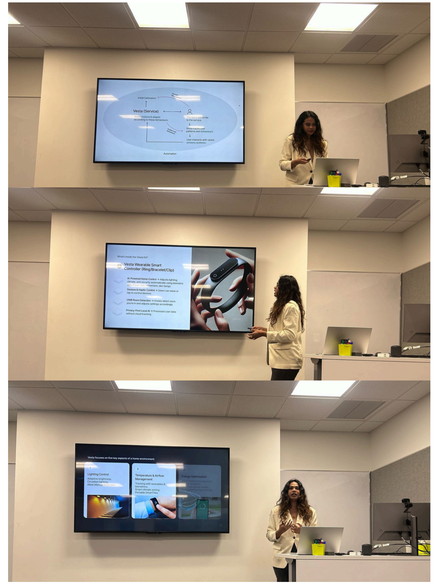
EPILOGUE

Design is never just about the end result—it's about the journey, the insights uncovered, and the impact left behind. Vesta began as a response to a market gap, a question of accessibility in smart home technology, and a challenge to rethink what home automation could be. It became more than just a product; it became a service, a system, and an approach to designing for real human experiences.

This project has pushed me to navigate complexity, to balance function with emotion, and to design not just for convenience but for adaptability. Throughout this process, I have learned that the best solutions are not always the most high-tech but rather the most intuitive—the ones that blend seamlessly into daily life, the ones that put people first.

Vesta is my vision of the future: a home that evolves with you, technology that understands rather than dictates, and automation that works without intrusion. It is a solution built not just for today's renters and early adopters but for a future where smart living is effortless, sustainable, and accessible to all.

But no idea exists in isolation. This project has been shaped by research, feedback, and iteration—by pushing boundaries while staying grounded in real-world needs. More than anything, it has reaffirmed my belief that design has the power to shape behaviors, improve lives, and create meaningful change.



Though this process book marks the conclusion of this chapter, the work is far from over. The questions I've explored here—about privacy, automation, user trust, and seamless integration—are ones I will continue to ask as I move forward in my career. Vesta may exist as a concept today, but its core ideas will continue to evolve and influence how we design for the homes of tomorrow.

This is not the end of Vesta. It's just the beginning.

-Reva Naik

Final Presentation Stills.

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Design isn’t just about creating products—it’s about shaping experiences, behaviors, and the future we want to live in. Vesta is more than a smart home kit; it’s a step toward effortless, adaptive, and sustainable living. The home should work for you, not the other way around.

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