Requirements Specification Document – Version 1
4/15/2025

Team ecoWattch

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Date: _____	Date: _____

Technological Feasibility Analysis

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1. Introduction

In recent years, the rise of AI has undoubtedly been exponential, and this trend has brought a significantly higher priority to the expansion of data centers. As a result, global electricity consumption is at an all-time high with no signs of slowing down anytime soon. AI-integrated technologies alone account for approximately 4% of the globe's electricity use. As primary consumers, data centers are expected to consume 1000 terawatt hours annually by 2030. This increase in electricity consumption naturally produces a proportional rise in carbon emissions, making the actions taken now more critical than ever if we want to preserve our beloved planet. Our team acknowledges this issue and has focused our attention on college campuses. Our campus, Northern Arizona University, alone spends roughly 15 million dollars annually on utilities, with more recent years averaging closer to 20 million dollars. As college students, this is very frustrating, not only because of the high emissions that result but also because our precious tuition money, which we've invested in this university, is being wasted on lights and computers that are simply sitting idle. These idle, unutilized electronics are the weak point that we aim to address with our project.

Today, most universities attempt to reduce electricity usage through campaigns, posted signs, and passive reminders for students. While these techniques may work to some extent, university administrators overlook the characteristics of college students; there simply isn't enough incentive or direct reason for us to engage deeply in that manner. To their credit, they've done a decent job raising awareness about the problem, but ultimately it won't matter unless they can sustain engagement to continue driving that change. Willow, our project sponsor, is directly involved in monitoring and managing electricity, even down to individual units inside building sectors. What they've realized is that traditional methods of energy conservation heavily rely on one's ability to interpret and understand the data being presented, which is simply not accessible in its current state. EcoWattch is our response to this challenge. If we can effectively gamify electricity consumption in a manner that resonates with college students from their perspective, we may be able to significantly reduce both electricity consumption and carbon emissions.

Our product focuses solely on dormitories, a key area of interest on campus. We recognize that college students enjoy a sense of togetherness, teamwork, and friendly rivalry, so we've chosen to embrace this by pitting dorms against each other in a streak-based leaderboard game format. Each dorm will compete to save more electricity by switching to LEDs, turning off lights during peak usage times, and so forth, with the winners receiving points they can spend in the app for cosmetics. By leveraging the enjoyable aspects of gaming, ecoWattch has the potential to make sustainability more engaging, involving college students in the conversation and maintaining their interest. Our sponsor, OP Ravi, has been incredibly supportive so far, guiding our ideation process, and as a result, we've developed a few select features. Our app will employ a streak and points-based game structure that pits dorms against one another rather than just individuals. With

these points, dorms can find themselves competing on the leaderboard, with special “Power-Hours” (the peak electricity usage times during the day) emerging to gain leverage against opposing dorms. Beyond the gamification elements, one major feature we aim to achieve is to streamline Willow's energy dashboard into our app, enhancing accessibility by eliminating data and features deemed extraneous in the context of this application.

Our goal is simple yet impactful: to make sustainability second nature for students. Through strategic design, gamification, and community-driven competition, ecoWattch encourages behavior change where it matters most — the dorms. It transforms abstract data into meaningful motivation and creates a new interaction between students and their shared environment. Through strategic design, gamification, and community-driven competition, ecoWattch encourages behavior change where it matters most — the dorms. This document outlines the core requirements to deliver a compelling and practical solution for reducing electricity consumption on college campuses.

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2. Problem Statement

Implementing sustainable energy practices at the user level is still challenging, particularly on college campuses, despite growing awareness of climate change and rising electricity bills. Colleges usually use passive marketing techniques like posters, emails, and awareness weeks since students frequently lack insight into how much energy they use. Despite their good intentions, many initiatives don't result in long-lasting behavioral change.

Willow, our sponsor, has created a cutting-edge energy monitoring system that can track electricity consumption in real time down to building units. But this data is still hidden behind intricate dashboards designed for administrative staff, not students. There is a gap between the availability of helpful insights and students' actual implementation of them, since the interface and data require technical expertise to interpret.

ecoWattch aims to close this disparity. Students are driven to change things, but they don't have the resources that are clear, easy to use, and fulfilling. Neither accountability nor incentives for action are fostered by the current system. We enable students to contribute to campus sustainability in a fun and quantifiable way by gamifying the electricity consumption process and providing streamlined feedback based on actual dorm-level usage.

The broader issue lies in accessibility and engagement. Students may be environmentally conscious, but are not exposed to real-time feedback loops that make their efforts visible or rewarding. Without tools that connect their daily actions to tangible outcomes, energy conservation remains an abstract concept. ecoWattch bridges that gap by turning dorm-wide performance into a shared, measurable, and impactful journey.

Engagement and accessibility are the larger problems. Even if they may care about the environment, students are not given access to real-time feedback loops that would highlight and reward their efforts. Without resources that link their everyday activities to observable results, energy conservation is just a theoretical idea. By transforming dorm-wide performance into a collaborative, quantifiable, and significant experience, ecoWattch fills that gap.

2.1 Current Workflow

1. Energy Data Collection

Electricity usage and power consumption are monitored and aggregated via Willow’s proprietary API, which collects real-time data from sensors across campus buildings, including dormitories. This stream provides an accurate and up-to-date picture of electricity consumption patterns at various scales without even having the hassle of taking the readings ourselves.

2. Data Aggregation

Willow processes this data on its backend systems and makes it accessible via structured API endpoints. These endpoints provide insights at varying levels of granularity, from building-wide summaries to sector-specific analytics. All data is handled internally, with no frontend delivery to students or mobile clients.

3. Administrative Access

Only university staff currently access this data through internal dashboards. These dashboards are optimized for technical users and provide detailed but complex information primarily used for maintenance, budget planning, and high-level trend analysis.

4. Limited Student Outreach

The current communication model is largely passive, consisting of occasional messages or signage with general energy-saving tips. Push notifications are minimal, and student access to their dorm's real-time usage data is nonexistent. There is no integrated mobile app or student-facing tool currently in place.

2.2 Key Pain Points

2.2.1. Lack of Student Access

Students cannot see their dorm's energy data in any user-friendly format, which limits transparency and accountability. This lack of transparency prevents any sense of ownership or accountability in their day-to-day consumption habits.

2.2.2. Technical Barriers

Existing dashboards are too complex for non-technical users and are not optimized for mobile platforms or modern UX standards. As a result, students find them unintuitive and inaccessible.

2.2.3. No Feedback Mechanism

Students are not shown how their behaviors (like turning off lights or using less heating) affect energy usage in measurable ways. Without seeing this cause-and-effect relationship, there's little drive to continue or improve energy-saving actions.

2.2.4. Limited Interactivity

Existing outreach lacks gamification, personalization, and incentive structures that would encourage frequent engagement.

2.2.5. No Behavior Loop

Without daily engagement, reminders, or rewards, behavioral change is unlikely to stick, even among environmentally conscious students.

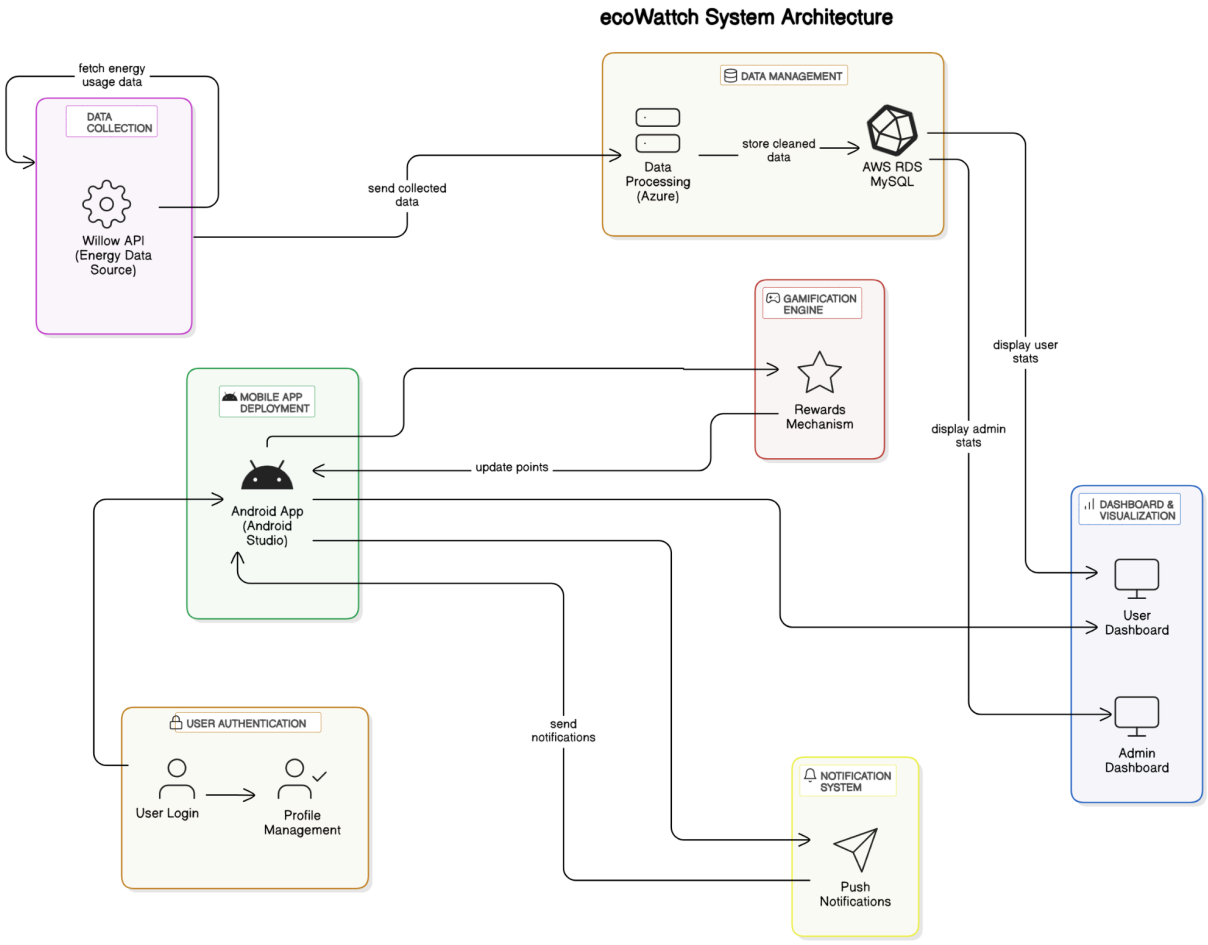
2.2.6. Disconnected Data Systems

Campus infrastructure systems rarely integrate with modern platforms or student-oriented apps, leaving a crucial data-accessibility gap.

2.2.7. Admin-Only Access

Current systems serve administrators exclusively and are optimized for complex institutional insights, not daily usability by the student population.

ecoWattch directly addresses each of these pain points by simplifying data, incentivizing action, and transforming passive consumption into active conservation—all through a mobile platform that students can interact with daily. By doing so, we make sustainability something students can track, understand, and take pride in. It bridges the divide between institutional monitoring and real student impact.


ecoWattch System Architecture
fetch energy usage data
DATA COLLECTION
Willow API (Energy Data Source)
send collected data
DATA MANAGEMENT
Data Processing (Azure)
store cleaned data
AWS RDS MySQL
GAMIFICATION ENGINE
Rewards Mechanism
display user stats
display admin stats
MOBILE APP DEPLOYMENT
update points
Android App (Android Studio)
DASHBOARD & VISUALIZATION
User Dashboard
Admin Dashboard
USER AUTHENTICATION
User Login
Profile Management
send notifications
NOTIFICATION SYSTEM
Push Notifications

3. Solution Vision:

To bridge the gap between electricity usage dashboards which traditionally require a data analysis background to fully understand and real college student engagement beyond just awareness, we proposed **ecoWattch** - a mobile-based application which streamlines intricate and intensive data into one, centralized platform, turning dormitory electricity usage into a competitive, engaging, and fun experience. By using Willows API, we can streamline and simplify data into competitive, habitual gameplay, effectively tapping into the competitive spirit of the average college student, leveraging and empowering them to make more informed, sustainable decisions, removing the need to be able to properly interpret data. Here are some key features planned for our MVP that will help get us closer to our envisioned solution:

3.1. Key Features for ecoWattch (MVP)

3.1.1. Simple and Non-Intrusive Login System

- Username and Password Login.
- Dropdown dorm selection (NAU Specific).
- No email or location data required to use ecoWattch.

3.1.2. Core Dashboard (landing page)

- Live view of current energy load at the user's selected dorm (updated every 10 minutes).
    - The current load is accompanied by a Meter-Based dorm system, which ties into the game elements. *Refer Below.*
- Yesterday's KWH total for the users' selected dorm.
- Weekly energy usage graph for users' selected dorm.

3.1.3. Meter-Based Point System

- Each dorm has a unique meter that tracks the current energy usage.
- The meter has an “optimal zone” (the average value between the ceiling and floor of the energy usage graph)
    - Staying within the “optimal zone” (+/- 20 KWH from optimal average) awards what is called potential energy (points) for the dorm. (25 points)
    - Above the optimal range results in potential energy loss, whereas below the optimal range usage awards even more potential energy. (-10 or +50 points)

3.1.4. Bi-Weekly Dorm Battles

- Dorms will be earning or losing potential energy (points) daily.

    - They can earn potential energy for staying within the “optimal zone” for the day (25 points)
    - Or they can either fall short and lose potential energy or push their savings beyond for additional potential energy in the “optimal zone” (-10 or +50 points)
- At the end of the bi-weekly schedule (Sunday @3am), the top 3 dorms on the leaderboard with the most potential energy (points), will be awarded to all tenants and converted into energy (spendable shop points individual per user).

3.1.5. Leaderboards

- Bi-Weekly leaderboard (dynamic)
- All-Time/Past Season leaderboards (static)

3.1.6. Energy Store

- After your awarded potential energy has been converted to energy, you may spend it at the energy store.
- Users can exchange energy for digital cosmetics.
    - UI Pallets
    - Name colors (for leaderboards)
    - More beyond the MVP scope

3.1.7. Daily Check-Ins and Trivia

- Additional energy can be awarded daily per individual via Check-Ins and Trivia.
- Check-Ins
    - Users can log in daily and complete 3 of 5 provided tasks (“Unplug unused electronics”, “Switch off devices before leaving class”, “Check current dorm load”, etc.) (5 energy tasks daily)
- Trivia
    - Users can answer 3 daily energy-related questions to earn additional energy. 10 energy for the first try, correct, 5 energy for the second and third. (5-10 energy per question, 30 max for the day)

3.2. How it Works (system specifics)

3.2.1. Main Processes

- Simplify and streamline dormitory-specific KWH readings from Willow into an averaged meter.

- Convert dorm efforts into potential energy (dorm points), maintaining and updating the leaderboard daily during the bi-weekly period.
- Reward individual user actions with energy via check-ins and trivia scores
- Aggregate dorm data into leaderboards and charts.

3.2.2. Data Generated

- Two-layer point system (potential energy and energy)
    - Potential Energy - Dorm Specific
    - Energy - User Specific
- Leaderboard ranks
- Dorm performance analytics
- Trivia Stats
- The system uses all of this data to encourage positive conservation behavior and reward efforts via store rewards.

3.2.3. Data Used

- Willow API - ecoWattch uses the Willow API to pull KWH data from dorm energy meters (as a whole, not per sector or room)
- Dorm engagement - ecoWattch uses users-per-dorm data to properly balance the competitive element, keeping things close to drive engagement.

3.3.4. Stakeholder Impact

- Students - Coming from a student perspective, ecoWattch offers a very fun, competitive, and engaging way to contribute to sustainability, which has the potential to bring more togetherness to campus. In the long run, this is where a lot of our tuition money goes (20 million annually on utilities), so reducing it can not only help the earth but also our college experience and education.
- Admins - With significant reductions to campus-wide electrical usage, we could see better distributions of profits on campus in a way that improves the quality of work for all administrators.
- Tradeoff - Students have the potential to increase their future quality of living on and off campus at the cost of occasional app interaction and electrical conservation efforts. Admins get further insight into electrical trends and efforts among students at the cost of potentially facilitating further rewards to drive engagement.

3.3.5. Why this solution?

- Many common solutions for saving energy come on an individual user basis, which can pose privacy and ethical issues. Where these efforts fail is in leveraging the competitive spirit of the average college student. Everyone loves to cheer on their favorite team at a game, or represent a group, it's fun, engaging, and competitive. We realize this and focus on collective dorm performance rather than individual sectors, lowering the barrier to entry, securing privacy, and sharing that accountability.

3.3.6. Future Potential

- ecoWattch lays down a universal foundation that could work at nearly any college campus where we have enough dorm energy data via Willow. With this, we could expand our efforts across the globe without changing much at all with the existing product, the scale is nearly limitless. With more integrations, different tasks, and more intricate rewards programs, ecoWattch has the potential to span beyond dorms to different neighborhoods and communities.

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4. Domain-Level Requirements:

ecoWattch is designed to facilitate energy data from Willow's API to users in a simple, streamlined manner via a competitive, interactive, gamified application. This application must meet high-level domain-specific requirements to effectively support student awareness and engagement.

4.1 Accessible Insights

Students should be able to easily view and interpret their dorm's energy usage data displayed to them in a way that is clear and doesn't require technical data analysis skills.

4.2 Engagement Via Gamification

The system must reward and promote sustainable behaviours via our game mechanics system: awarding points, leaderboard bragging rights, unlockables, to encourage long-term term meaningful participation.

4.3 Education through Competition

The competitive elements of ecoWattch should drive users to pursue daily interaction with the product via check-ins and trivia, building habitual routines that improve user impact and retention over time

4.4 Progress Visualization

Users need to be able to see their impact in real time via their dorm's performance measured on the meter and leaderboard, as well as their contribution via provided metrics and graphical visuals.

4.5 Customization and Cosmetics

Engagement should be driven via an incentive tied to the energy shop, providing users with methods by which they can show off even more on the leaderboards via profile cosmetics and or pallets.

4.6 Notifications and Feedback

Users should receive feedback via local notifications to remain in the know about their dorm progress, ranking, and daily check-ins.

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5. Functional Requirements:

5.1 Energy Usage Display

- The system shall retrieve real-time data via the Willow API for each dorm.
- The system shall effectively visualize data via simple, intuitive graphics.
- The system shall update the data every 10 minutes

5.2 Points/Rewards System

- The system shall reward the proper amount of points to users for completing daily tasks, trivia, and or energy reduction efforts.
- The system shall effectively store, manage, calculate, and display users' point balances.
- The system shall deny users the ability to reach negative points individually and in dorms

5.3 Notification System

- The system shall send opt-in/out non-intrusive local app notifications for important metrics and events.
- The system shall allow users the ability to customize notification preferences
- The system shall send users reminders for check-ins and general tips

5.4 Cosmetic Shop & Customization

- The system shall include a digital shop to spend points (energy) where users can redeem cosmetic items.
- The system shall properly inform users about the item via a preview before purchase
- The system shall allow users to equip and utilize the items purchased from the shop

5.5 Daily Engagement Features

- The system shall allow users to check in daily with 5 tasks that earn points.
- The system shall log check-in history and frequency.
- The system shall notify users when they can check in again.

5.6 Log-in Features

- The system shall allow users to create an account with a unique username and a password.
- The system shall allow users to log in with their username and password.
- The system shall securely store usernames and passwords with appropriate encryption.

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6. Performance Requirements

6.1. Response time

The app must have a quick response time to user interactions in order to maintain user engagement. If the app is too slow, users will not want to use it, and will no longer be contributing to energy reduction on campus.

Measurable outcome: Button presses will have a response time of ≤ 0.1 seconds.

6.2. Information security

The system must securely store user data in an external database. All data must be secure and encrypted to ensure integrity of data storage.

Measurable outcome: The user's log in data will be stored securely to ensure no data leaks

6.3. Points

The system will keep track of user points and dorm points separately, as they are used for separate rewards. User points do not need to be stored in a database since individual user rewards only affect that user's instance of the app. Dorm points are displayed on a leaderboard and can be seen by all users, so they must be stored in a separate database.

Measurable outcome: User points will be stored locally using room databases in Android Studio, and dorm points will be stored in a Microsoft Azure database.

6.4. User engagement

The app must maintain user engagement to maintain energy reduction. It will feature daily check-in tasks and tips for energy reduction to help users consistently work towards lowering their energy usage.

Measurable outcome: A majority of users will open the app once a day and do at least one activity with a measurable effect (e.g., turning off electronics or learning methods of energy reduction).

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7. Environmental Requirements

7.1. Android app

The client requested a mobile app, and together with our client, we decided to create an app for Android devices. While iOS devices are certainly more popular among college students, having even just a few users will contribute to lowering energy usage overall. Developing an Android app is also free and allows us to use Android Studio for development. We opted to code in JavaScript, as it has a much shorter learning curve than the alternative, Kotlin.

7.2. Willow API

We will use the Willow API, provided by our client, to access information about energy usage at NAU. As Willow does not yet have detailed data on every building on campus, we opted to only consider energy use in on-campus dorms.

7.3. Microsoft Azure

Our client is able to provide us with access to Microsoft Azure, so we will be using a SQL database via Azure. We will use this database for any external storage of information, such as user account info and dorm points. It is similar to AWS, which our group does have some experience with, so it should be fairly easy to work with. We are not currently planning to use any other aspects of Azure.

7.4. App Contents

The main purpose of the project is to make a game out of energy conservation, so this will be a main focus of the app. The specific game elements of the app have been mostly left up to the team, however. We have also been asked to include an energy dashboard in the app, allowing users to see how much energy is being used by dorms across the NAU campus.

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8. Potential Risks

This project consists of an app whose main purpose is to spread awareness of wasted electricity, as well as to encourage people to lower their carbon footprint. With this main goal in mind, the risks that can arise from this project are not very dangerous. Put simply, our app failing will not endanger the life of anyone. This does not mean there are no risks to consider while developing the app, however, the impacts of these risks are not as serious as other capstone projects.

8.1 Data Security

One risk to consider while developing our app is data security. We will be having our users sign in to our app, and so we will need to consider the potential risks associated with handling user data. The biggest risk associated with this is that a malicious hacker gets access to someone's username and password for their account on the app. This will not be very important at all, as the app will be completely free to use. No credit card information or anything super important will be entered into the app. The worst piece of information that could get leaked could be their name if they decide to use it for their username, but this is not a big concern. Users will be asked to make their password specifically for this app. While the potential ramifications of a data breach are minimal, people appreciate having all of their data securely stored.

8.2 Willow API

Related to security, we also need to make sure we call the Willow API in a way that makes it difficult for more malicious users to use in an unintended way. While the Willow API is available to many people if requested and paid for, it is not open source. This means that our app will need to keep the data it gets from the Willow API secure, as to not give a valid access token to someone that might use it for their own personal projects. The worst that could come of this if our security measures are breached is that our access token is given out to a malicious user who might use it to flood the API with calls, and potentially make their API much slower. This is our most important risk to keep in mind, as if this happens, Willow may decide to cut ties with us, and then our whole project would die.

8.3 Unhelpful or Inaccurate Information

Another potential risk is if a user is given unhelpful or inaccurate information as to how they are using electricity. While this would be unhelpful for the user, the app would never be able to say anything to harm themselves. Our app's suggestions are pre-written by the developers, and so the worst that could happen is that the user is given a suggestion that does not apply to them, or has already been given to them. The worst that could come from this is the user getting annoyed or

mad at the app, or the user wasting more electricity. While this is counterproductive to the goal of our app, no real harm will come of this.

8.4 Competitor

If a competitor brings a new product to the market that is similar to our product, there is a risk that our product will no longer be relevant. A competing product or app could potentially be more interesting or more compelling to the average college student, but us being first is a big factor in mitigating the risk of the app dying because of a competitor. People will have their points saved up on our app, and potentially have cosmetics earned in our app, and they would not want to lose all of their progress. A competitor would need to offer something truly remarkable and different from our app to make users switch from our product.

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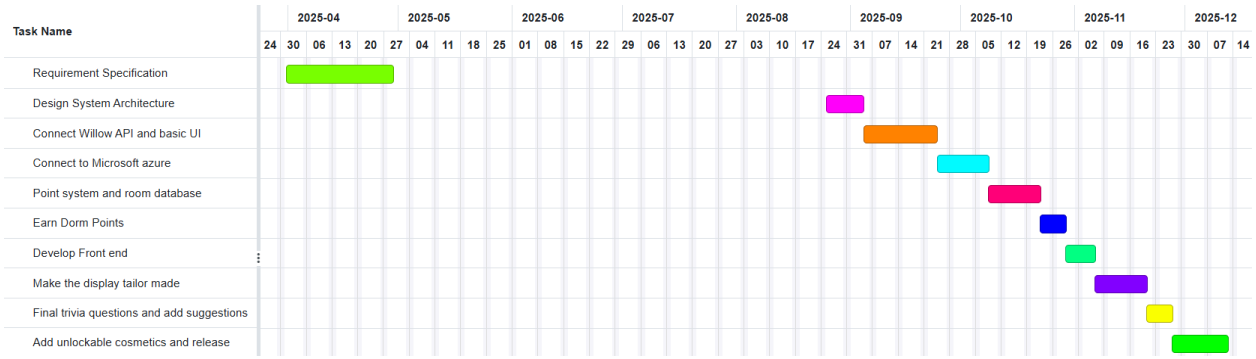
9. Project Plan

The development of this app will mirror the agile method of product development. This product will be made in many small parts, where certain milestones will need to be reached. These milestones are as follow:

1) Define/Finalize requirements
2) Design system architecture/finalize how the system will function
3) Create the front end of the app, including finalizing the format of everything
4) Connect the Willow API to the app, and have some data displayed in the app that came from the Willow API
5) Connect Microsoft Azure to the app, and get the login system working
6) Make it so the information that is displayed for each user is tailored to them based on which dorm they reside in
7) Create the point system with the room database and some example trivia questions implemented
8) Finalize the trivia questions and suggestions
9) Add the functionality where the user will earn points based on how their dorm performs each 2-week period
10) Add the unlockable cosmetics and finalize the app for release.

While the milestones may be done early, as we will have summer vacation to work on the project if we wish, the due dates for the milestones are displayed in the following chart:



While this schedule may look tight at first, it should be kept in mind that many of these milestones are quite trivial. Connecting to the Willow API is given a large block of time, when it really shouldn't take that long. This is to allow time for testing to be done for our app, as well as extra time in case some milestones are not completed on time. We also have a significant amount of time to work on this project during the summer months of May, June, July, and the beginning

of August. As stated previously, these months can be used to start the initial phases of development, in order to make our deadlines during the fall semester less tight.

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10. Conclusion

In summary, our project aims to develop an Android app that students can use to track their electricity consumption, as well as encourage them to lower their electricity consumption. This encouragement is done with a gamifying aspect of lowering consumption, where students are rewarded not only by learning about ways to lower their consumption, but also by making their building use less energy. Our app aims to create a fun and intuitive experience for students to help the planet, and create a template that could, in theory, be used by other universities to help lower their carbon footprint.

The main reward structure we will put in place for the students revolves around points, what we call “energy”. This energy can be gained by completing daily tasks in the app, as well as keeping the electricity consumption of the dorm they reside in low. This energy can be spent on cosmetics within the app, giving the students a goal to work towards.

The purpose of this document is to discuss exactly how we aim to achieve this lofty task, as well as create a plan to set us up for success. This document has been instrumental in our development process. It gave us time and a reason to discuss many of the finer details of the app and its mechanics. It also serves as a way to explain to our client Willow what exactly we intend to do for them in the near future.