Final Design Report

Ceres Smartphone Application

ME 589: Sustainable Design of Technology Systems, Fall 2013

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Abstract

Ceres is a smartphone application which empowers users to reduce their transportation related environmental impacts through a competition. The point system in the competition will be indicative of the actual environmental impact of the specific behaviors. Ceres will be simple to use—behaviors will be verified independently through accelerometer and GPS technology. Financial viability will be through partnerships with companies and public transit authorities. These partners will advertise their products through the application and provide incentives, in the form of discounts for the most active users. Through Ceres, an empowered, educated, and incentivized population will act more sustainably.

Executive Summary

Ceres is a smartphone application designed to inform users on their environmental impact while incentivizing them with points for sustainable behavior. Transportation behavior will be the lead design.

Long-term user involvement is critical for this product to have a positive environmental impact. Therefore, we conducted ethnographic research on potential users regarding smartphone usage and sustainable behaviors. Survey data showed that while users may decide to use an app depending on the privacy policy, many do not believe their current apps to be private. Ethnographic data was also collected from transportation experts to understand how public transit decisions are made. The results from the ethnographic research were translated into product requirements, and determined from the perspective of each stakeholder. The project requirements were ranked based on relative importance.

Functional decomposition and integrated design were used as concept generating tools. These functions include the medium used to distribute the information, what incentive structure is used, what incentives are used, verification of user behavior, and sources of revenue.

The potential environmental benefits of our application were evaluated using life cycle and census data. Generally, if our product encourages 5% of users to change their transportation behavior, approximately 5% of total greenhouse gas and criteria air pollutants will be mitigated. The large exception to this rule is SO_2 which increases as more users utilize public transit due to the higher SO_2 emissions from rail transit. Therefore, bus transit should gain more points than rail, and biking or walking should have substantial more points than the other transportation methods.

Our alpha design is a simple 4-screen interface. Users have access to their personal environmental impacts, their points, the points of other users in their contacts, and, for a price of $1.99, they can access detailed environmental impact information. The advertisement will be integrated with sustainability advice.

Ceres will begin by marketing to customers who already engage in sustainable transportation as they will most likely be the first users. These users will be reached through a marketing campaign advertising on buses and at bike stores. These users will quickly see discounts and rewards, increasing the app's popularity. The early users will be used to attract more partner companies delivering the discounts. Our company will attract these companies by initially offering a discounted rate to advertise through our app.

Ceres is expected to become financially independent after 1.5 years of operation and become profitable after 2.5 years. Launch and expansion of Ceres is broken into three phases. The first will see the creation and development of a prototype with funding ($100,000) coming from personal funds, friends, family and investors. Phase 2 will see personnel expansion and a significant demand in required funds ($750,000). Phase 3 will be the final expansion of the company with yearly expenses ($1-5 million) being divided into salaries, overhead, technology and legal.

Future work includes establishing firm partnerships with companies and receiving feedback from programmers. This feedback will establish what will work in the app and what has to be redesigned.

We believe with widespread adoption of this product we will educate our users while engaging them in sustainable actions.

Introduction

Many attempts to introduce environmentally sustainable designs have been attempted, due to the increasing importance of sustainability. User participation and public willingness to accept and participate in these attempted changes is one of the largest requirements for a social change towards sustainability. However discovering tools that influence individuals behavior towards change is still a challenge, as motivations are not exactly known. One aspect of the research done by Ståhlbröst et al. attempted to discover what would motivate users[1]. Some of their conclusions stated that users want to know exactly what is saving energy and want to compete with their neighbors. In addition, research has shown that personality traits such as a sense that you have control of your surroundings, an internal locus of control, are important in environmentally related behavior changes[2]. The tools which are used to change environmental behaviors do not incorporate this research.

Current smart phone applications track and monitor energy usage, without rewarding the user for their efforts or giving the user clear information on what their environmental impacts actually mean. Simply having the ability to monitor usage is not enough motivation, which Ståhlbröst et al. explained. Other apps help users find “eco”-products, such as LED lights or more sustainable appliances. These apps require the users to have already made a conscious decision about becoming more sustainable, and thus do not influence the users’ behavior.

We have conducted ethnographic research on the users, and interviewed public transit experts. This research informed our need and much of this research was used to generate requirements and specifications for a sustainable design. Concepts were generated and evaluated against these specifications. Our team has developed a smartphone application called Ceres. Ceres is designed to inform users of their environmental impact while incentivizing them with points for sustainable behavior. Incentives tend to alter social behavior regarding sustainability. Through partnerships with local businesses, loyal users can receive benefits beyond points such as discounts. These partnerships will financially support the app. The environmental sustainability of our product depends heavily on users interfacing with this product. While this application can be applicable to a wide range of behaviors, we will focus transportation.

Ceres will evaluate an individual's performance for environmental efforts, rewarding the user with points that are used to compete and compare with friends. Loyal users will receive more points, and be able to use these rewards at partner businesses. This project will both inform users on environmental impacts and provide users with an incentive system to promote sustainable behavior. While our team will focus on one category, transportation, we plan on expanding once validation is complete.

Baseline description

Project goals

In order for this application to be sustainable it needs to be economically viable, have user buy-in, and have measurable environmental impacts. Critical to our success are incentive structures to increase user participation. In order for the project to be economically viable, the application needs corporations and municipalities interested in partnering and advertising. Partnerships which provide incentive structures

to the user (necessary for user buy-in) require a verification scheme for the user. Therefore, preliminary selection of a verification structure was conducted. Many stakeholders were interviewed to further validate user buy-in. Lastly, environmental impacts of user behaviors were assessed to develop point structures and educational tools within the app which will reduce the users' environmental footprint.

Economic Viability

Economically, we identified the business plan of similar smartphone applications, such as Mint.com and Foursquare, and adapted it to Ceres, details of the business plan are shown on page 29. Mint.com is a tool to track and organize personal finances that is free for users. It utilizes lead generation to make money. By analyzing user finances and spending habits, it has the ability to recommend credit-cards, bank accounts and other financial-services that would save the user money[3]. These recommended and advertised accounts or credit-cards are from banks that provide most of Mint's revenue[4]. Due to the personalization of the recommendations, Mint achieves a 19% higher click-thru rate than conventional banner ads[4]. This same logic can also be applied to phone bills, cable, by comparing and finding where the user can reduce their bill. The personalization of recommendations based on lifestyle and habits can be applied by making suggestions to the users of different steps they can take to be more environmentally sustainable. For example, recommending to the user to purchase LED lights or new insulation to reduce their energy bill.

Another app to be used as a financial model is Foursquare, a location-based social networking app. An important aspect of Foursquare is their heavy loyalty reward system, so users that frequent the app the most, receive the most benefits. Due to its loyalty reward system, Foursquare is partnered with different brands or stores that allow users to receive benefits or discounts. For example, American Express offers discounts at specific restaurants or shops when users check-in with the app and subsequently use their credit-card there[5]. Other examples include Starbuck's offering the mayors (users who have visited the store the most) coupons on drinks, and BART regular riders being randomly selected to receive a free ticket[6]. Including a heavy loyalty reward program that rewards users with discounts and coupons can easily be applied to Ceres. For example, a user frequently riding their bike to work can be rewarded with a coupon for a bike tune-up. This also acts as a strong incentive to continue using their bike.

Environment Importance

The environmental impact relies on the users. Many aspects of our application will encourage users to engage with our product. Our application will provide incentive structures, a social and cultural platform to encourage usage, and a sense of empowerment (vital for learning about sustainability and changing of behaviors)[2,7]. The focus for our team is the use of bikes and public transit as a mode of transportation. Environmental benefit of using bicycles as a transportation mode is fairly clear, as transportation is a leading cause of greenhouse gas emissions. According to the EPA, nearly 30% of all GHG emissions were due to transportation in the U.S.[8], detailed environmental assessment of transportation is on page 17.

Social Feasibility

This product must alter user behavior towards sustainability to be successful. Our application also empowers users by informing them of the impacts of their actions, and the combined improvements of all users. Biking has become increasingly encouraged worldwide, often through the implementation of a

bike-sharing program. For example, NYC Citi Bike, which became public in May 2013, shares its data. Bikes are anchored to one of the bike sharing stands spread around the city. A user pays to release the bike and ride the bike around the city. They then drop off the bike at any available stand, meaning they are not required to drop off the bike at the stand at which they undocked it from[9]. Figure 1 shows the daily miles logged in the system. On its busiest day, approximately 42,000 trips were logged[9]. Even though tourists and not commuters may account for this usage, tourists who use bikes as their transportation mode rather than public transportation or cabs still have a positive environment impact. This evidence supports the idea that if resources are readily and easily available for use, users are capable of changing their behavior.

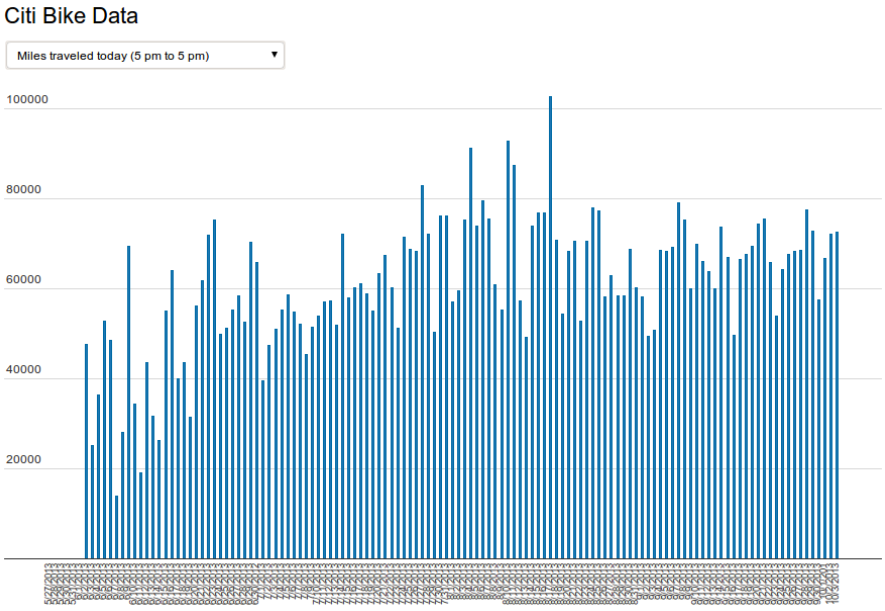

FIGURE 1: CITI BIKE DATA- MILES TRAVELED SINCE ITS IMPLEMENTATION

Marketing

Many apps attempt to inform their users of energy savings or find energy saving products[10]; however energy savings is a simplistic view of sustainability. For example, lowering home energy consumption by buying newer appliances may not be sustainable; considerations of the embodied energy of these products should be included in an assessment. Nevertheless, many of these energy-centric applications have properties that may be incorporated in these smartphone applications. Energy tracking apps such as "Kill-Ur-Watts" and "Opower" work like a mobile electric meter; they tell you how much electricity you have used throughout the day to help you lower your energy consumption[10]. Besides energy saving applications, incentive structures have been incorporated into other applications, including FourSquare[5,6] and Field Agent[11]. In the latter, users solve missions around their neighborhood and are rewarded with $2 to $12 via PayPal. Ceres will combine the advantages of these apps, educating consumers about sustainability and providing users with rewards, which will encourage users to use it.

Aside from applications, there are many ecological footprint calculators online created by organizations such as the World Wildlife Fund. However, as reviewed by Franz et al. these calculators can create a

feeling of "fatalistic pessimism"[12]; the behavior changes suggested have very small impacts compared to the overall ecological footprint of the average person living in the developed world. Since these users have an inherent ecological footprint, even if they adopt all possible options to lower their ecological footprint, they still live beyond their ecological means. Franz suggests a customized accountability structure for the user that emphasizes the connection between individual actions and environmental impacts. Ceres creates this accountability structure and unlike these footprint calculators rewards users for taking the steps available to them to lower their ecological footprint while teaching them the environmental impact of those actions. Further, in order to provide the necessary sense of empowerment to encourage sustained behavior, the reduced environmental impacts of all the users combined will be displayed in the application[2,7,13]. We will also show impact based on geographic region, (i.e. the combined environmental impacts for your city and state). Our application avoids pitfalls of other applications and technologies seeking to educate consumers about their ecological footprint.

Engineering

Above are the opportunities for Ceres in the current market; however we require specific technologies to fulfill the intent of the application. The activity recognition applied by Google Maps can tell if a person is walking, biking or driving[14]. This technology can be used to verify what kind of transportation a person is taking and for how long. This type of technology has also been applied in calorie counting and healthy living apps such as Human to encourage walking and biking[15]. In partnership with public transportation authorities, we will be able to reward people that take public transportation. For instance, there are many official route apps such as "Magic Bus"[16] used for University of Michigan buses. Our application may interface with these systems to verify public transit use (i.e. if Ceres users are moving with the bus's signal). Public transportation authorities have partnered with other apps to provide incentives, such as the Bay Area Rapid Transit (BART) and Foursquare[6]. Toogether is an app that helps people carpool[17]. Users upload their ridership and cost sharing preferences. With improved device location detection[18], smartphones can be located which may help with verification strategies for Ceres.

Gaps

In order to reward people, we need to have company partners. In order for there to be true partnerships, the companies have to see benefits in the form of increasing corporate social responsibility and increasing revenues. Ceres must benefit from the incentive structures provided by the companies. Most likely, our partnerships will need to improve sales, not just improve company image. How much money is needed to keep Ceres operating, including rewarding people, is a complicated financial structure. The most similar example of this financial structure we found is bicycle benefits[19]. They seek to promote biking and helmet usage. Bikers purchase a sticker for five dollars. When they show this sticker at partnered stores they can obtain a discount of about 10%. However, the companies have an opportunity to make money ($2.50 per sticker) so their only investment is the discount they offer. This is one example of financial structure where other company's corporate responsibility and advertising are intertwined into the financial basis.

Design Ethnography

Given that much of our product is trying to change behaviors, ethnographic research was an important part of this project process. Our initial guiding questions in our ethnographic research were: what is the users' preferred method of transportation, and how do users engage with their smartphones?

TABLE 1: STAKEHOLDERS OF PROJECT

Group	Description
Users	Smartphone owners interested in reducing environmental footprint
Stakeholders	Utilities, company/municipal partners, public transportation authorities
Experts	Manufacturers, company/municipal partners, app designers, LCA experts, smartphone designers
Client	Users and company/municipal partners

Table 1 shows the different contributors to this project. Some contributors overlap between the different groups. The users are smartphone owners interested in reducing their environmental footprint. From this group we want to obtain information about how people engage with their environment and understand the impacts of these behaviors, and establish the marketability of this product. The stakeholders include: utilities interested in understanding how people use electricity and gas and what motivates them to reduce their output, company partners that contribute in multiple ways but are vital to the economic sustainability of the product, and public transportation authorities, a type of company partner that may also be interested in the data we collect on how and where people use public transit and bike paths. Each of these stakeholders provide important opportunities for synergy that can make the product better for the user, make the product financially viable, and can integrate the product into city planning. Experts include manufacturers, company/municipal partners which understand the environmental impacts of their products, smartphone designers who understand where the technology is moving and the future potential for verifying behaviors, app designers who would be interested in designing a user interface, and LCA experts because we want the points to be proportional to actual environmental impacts. The experts will provide information both on understanding how users want to interact with electronic apps and information on the environmental impacts of different behaviors we will incorporate into the app.

We have synthesized existing knowledge regarding other products, how people are motivated to change their environmental impacts, and the types of incentive structures that have worked with some behaviors (Baseline description above). Interviews were used for obtaining information from the users. We targeted a wide range of people.

We interviewed 8 users to begin establishing the marketability of our app. We left it up to each team member to design their own questions to start the interviews and conclude the interviews that they felt most comfortable with that user. However we wanted to make sure all team members engaged in conversations about smartphones and transportation. Despite that our ethnographic data collection is US centric eventually we want our app reach across cultures to have the largest impact.

The details of the interviews and observations are shown in the Appendix 1. From our interviews we gained some interesting information. The people we interviewed for the most part were in our age range, and therefore were familiar with smartphones and used apps often. One important aspect of the apps is that they have to be convenient and easy to use. People are probably not going to engage with our application if they have to be constantly updating their behavior. We incorporated this requirement into our specifications for both the application and the verification scheme. For the most part, the people we spoke with whom did not drive did so out of necessity, i.e. did not own cars. It is possible incorporating driver behavior may be an important way of changing transportation behaviors, since people with an ability to drive tend to drive. The technology to do so exists[20]. This could be incorporated into future design iterations as our focus for our lead design is to reduce driving since this behavior has much more significant environmental impacts.

The users we interviewed also did not seem to be overly concerned with privacy, despite one of them having potentially had their privacy violated. They did not like apps that tried to connect with facebook or other social media, but were not too concerned with how the apps actually use the data they collect. Issues with privacy are addressed in a later section. Nevertheless, we recognize that this may be a result of our interviewed users being in a generation that regularly discloses their personal information through facebook and other social media. We have decided to follow National Institutes of Standards and Technology guidelines on firewalls[21] and allow users to own their data. Their transportation data will not be shared without their permission. Users can request to delete their collected personal information from our servers.

Lastly, there was a universal interest from users in our product and specifically the incentive structures we will provide. It seems users are more likely to respond to positive reinforcement (i.e. coupons) rather than being punished (i.e. have to pay). This behavior was verified with a survey we conducted, the results of which are addressed later. Users also want the incentives to be proportional to the amount of effort required on the application, emphasizing the need for an easy to use application that requires minimal user input.

We also interviewed an expert in transportation planning and modeling. From this we learned that decision making in transportation is very complicated. The public transportation networks are very segregated by community. This makes for segregated funding for transportation projects. There is an entire industry dedicated to transportation data collection. Therefore, it is unlikely that our application can actually be used for transportation decision making, as there are well-established data collection structures. She also noted that partnerships with public transit authorities may be difficult as every community may have different people running their transit (different agencies control bus and rail in the Bay Area for instance). It may be challenging to offer transit related rewards to all users; we may have partnerships with some agencies but not every agency a user may utilize.

We have found that many different kinds of businesses are interested in advertising to “green” customers through bicycle benefits. Bicycle benefits is an organization in which users purchase a sticker for their helmet for 5 dollars, the users then receive discounts of at least 10% when they show stores their helmet. Many businesses in our local community have signed up to engage with this organization.

Because of the complex stakeholders involved in transportation we will expand our advertising and reward base beyond public transit authorities.

Persona

Elliana is a 27 year old single female and Ann Arbor resident with a master degree in health information technology. She manages a small team at the University of Michigan hospital and helps improve the electronic health records of patients. Part of her job description is ensuring patient privacy, she therefore values privacy. She has a median socio-economic status and tracks her financial affairs and budgets partially by using coupons to save money. She is trying to save up to purchase a home therefore she takes "a penny saved is a penny earned" to heart. She chooses to live close to the hospital because although she owns a car, she hates driving in traffic. In a typical working day she wakes up, checks her email on her smartphone while making coffee, showers, and bikes to work. In the winter she will usually choose to drive. She spends most of the working day using technology. Moreover, technology and her smartphone play an important role in Elliana's daily life; she uses apps to stay in contact with her friends, follow news, and entertain herself. When she gets home she usually tries to cook a simple meal and watch a movie. On the weekends spends her time socializing with her friends and loves to spend time outdoors. She has always loved outdoor activities such as hiking, rock climbing and particularly, biking. Elliana is conscious of what people think of her, and is described as an optimist by her friends, family and acquaintances. Elliana likes to stay on top of the latest trends and share these with her friends. While she values the environment, cost and convenience drive her environmental behaviors.

Project Requirements and Specifications

Our project aims at reducing users' environmental impacts related to their personal transportation. We have developed project and product requirements with the assumption that our product will be in the form of an application (although other delivery concepts were generated, they were eliminated because of the relative advantages of integrating with a device users always have). We have assumed that the product will first be available as an iPhone application, with Android and Windows applications developed at a later stage. An iPhone version will be created first since the hardware (GPS and accelerometer) is uniform.

Our potential company partners and our users have very different requirements. From our ethnographic data collection we found users emphasized an easy to use application which they do not have to log onto to run. They also were very interested in gaining rewards. Although the users we spoke with are not concerned with the security of their data, we think other users like our persona would be, so we incorporated this into our requirements as well. Users are also less likely to use the product if it is not well integrated with the smartphone. Our company partners want to give out useful discounts; therefore behaviors need to be verifiable. Furthermore, we may also want company partners which are national companies and therefore a universal verification that would function in all cities is important. Company partners are also interested in the space dedicated to advertising and the data on the "click through" rate of advertising. Lastly, the purpose of our company is to reduce transportation related environmental pollution. In order to do so we need our users to engage with our product enough for

long-term behavior modification. These requirements were translated into specifications shown in table 2.

TABLE 2: REQUIREMENTS, SPECIFICATION AND IMPORTANCE FOR USERS AND COMPANY PARTNERS. BLUE REQUIREMENTS RELATE TO VERIFICATION; GREEN REQUIREMENTS RELATE TO INCENTIVE STRUCTURE; WHITE REQUIREMENT RELATES TO BOTH

Stakeholder	Importance	Requirement	Specification
User	9	Easy to use	3 number of clicks to get to feature
	9	Precise location signal	Detect user within 50 feet of where they actually are
	6	Incentive structure	Most active 30 percent of users obtain rewards
	6	Battery life can't be drained	No less than 7 hours on app, including background processes will completely drain battery.
	6	Data security (Y/N)	Data will not be shared outside of app without user permission Data can be shared with user and can be deleted at the user's discretion. Firewall meets NIST standards[21]
	6	Informative (Y/N)	Informs user of personal impact and ways to mitigate it
	3	Stylish Design (Y/N)	Stylish Design
	3	Verification integrated with smartphone	0 additional hardware required
Company partners	9	Collect data on advertising effectiveness	10% click-thru rate of advertisement
	6	User-independent verification (Y/N)	Behaviors are verifiable independently from the user
	6	Advertising space	Every 5 clicks advertising is delivered in the form of advice
	3	Universal verification (Y/N)	Any location and transportation type can be verified
Environment	9	Environmental benefit	5% reduction in driving by user base

Data security, informative interface, stylish design, and universal application have yes or no specifications. We have defined data security as being compliant with the National Institute of Standards and Technology firewall guidelines and giving the user ownership of the data; they have the ability to obtain and delete any data we have stored. Universal application is defined as an ability to identify all forms of transportation, with the exception of carpooling which we are not considering for the alpha design, and an ability to function in all cities in the US. We defined informative as telling the user their

personal impact and ways to mitigate it. We imagine conveying this information both through a point structure and through graphical depictions of the users' impact over the last 10 days.

We have split up our design process into three separate functions: usage/ incentive structure, the verification, and the environment. Our specifications have also been split to fit within these functions.

For the incentive structure function the most important attribute for the user is ease of use, the most important attribute for the company partner is the data on effectiveness of advertising, therefore these were ranked high. The user is also very interested in gaining a lot of rewards for their behaviors. The companies are also interested in the exposure of the user to their products, in the form of advertising space. It was important to one of our users that the product provides useful information about sustainability. Since this was specifically brought up we thought it is important for some users, but not all. We believe a stylish design may be important to some users and for our ability to market the product. This did not specifically come up in our ethnographic data collection so it was ranked low.

For the verification structure we ranked ease of use high. Precise location was also ranked high as it is necessary for the application to understand the users' behavior and provide advice. Data security, user-independent verification, and effect on battery life were all ranked in the middle. Battery life is important, but again, it was not something our users mentioned as being important in how they select apps. User-independent verification is important to our company partners. Integration with the smartphone and universal application were ranked low. Since this is our lead design, the universal application may not be critical as we can add geographic locations and modes of transportation as we add other sustainable behaviors. The integration with the smartphone is important to minimize the material usage and increase the sustainability of our product but this is not vital to any of our stakeholders.

For the environment function, we cannot predict the rate at which users will stop driving. This has more to do with the rate at which people choose to change their behavior, and less to do with engineering decisions. While we are aiming for 5% reduction in driving, we have analyzed the impacts of only a 1% or on a more optimistic 10% reduction in the section called Environmental Improvement and Uncertainty from Alpha Design.

We discussed some competitors that try and save energy (OPower and Kill-Ur-Watts[10]) or try and calculate the user's ecological footprint[12] in the Baseline description; however we think our more important competitors are ones that try and change transportation behaviors and incentivize alternative transportation such as bicycle benefits[19]. Many businesses in our local community have signed up to engage with this organization. This organization is trying to incentivize helmet usage and reward bicycle riding. We will have to compete with this organization and organizations like it for partnerships, as it is unlikely that a business will want to partner with both our application and an organization like this. Our product however, has the advantage of being technology driven and verified as well as being easy to use. It will also be free for the user. Further, the advertising for our application is much more direct than the advertising afforded by this organization.

The baseline we defined for this project is how commutes to work are split between transit mode now: 76% of people drive, 10% of people carpool, 5% of people use public transit, and 0.6% bike[22]. We found resources to quantify the use phase air emissions associated with these transportation types per passenger mile traveled[23], mileage associated with these transit modes[24], and national split between public transportation types[22,24]. The environmental impact from this baseline is discussed later.

Sustainability Evaluation Process and Status

This section describes a sustainability evaluation for this product. While more evaluation may be necessary, for instance validating that competition and incentive structures motivate users to change their behavior; this section outlines some sustainability concerns and potential triumphs.

Use context

Our product is used while the client uses his/her phone. Users will choose to use our product for the opportunity to save money. The intention is that in trying to save money, users will learn about their personal impact and begin to change behaviors besides transportation. This likely requires long-term use of the product. We envision the product requiring minimal active usage (a few minutes a day for the most engaged users). However to validate the transportation behaviors our product may need to be constantly running in the background of the phone. The product is incorporated into existing smartphone technology and therefore a smartphone is a requisite. Our product will initially be deployed in cities in the U.S., expansion to other developed countries will be slow.

Overview

The servers required to host the software for the app most certainly have an environmental impact with regards to raw materials including oil to produce plastic, and likely some rare minerals with intensive extraction processes), manufacturing processes, use-phase energy, distribution, and disposal. This product is merging with a product that people are already using, smartphones; therefore, the multi-functionality of our product reduces the environmental impact. Nevertheless, the environmental impacts of the manufacturing, distribution and disposal of the smartphones are noteworthy and likely far outweigh the environmental impact of the servers. Additionally, from a social sustainability framework it should be noted that these adverse pollutants have long been seen to correlate with low-income, high minority neighborhoods[25,26]. Therefore, mitigating transportation related pollutants may have a more positive impact on minority and/or low-income populations. Additionally, our product has a social component—users can compete with one another for points and can understand the impacts of their community and network. If we are successful, this product may make environmental awareness trendier and educate the public on environmental impact categories.

Eco profile

As mentioned earlier, our product may need to be constantly running data acquisition to verify transportation behaviors. Other apps attempting to track transportation behaviors (for fitness applications) have been shown to drain the battery and therefore increase the use-phase energy consumption of the phone[15]. We will try to find ways to minimize this source of impact because it also decreases user functionality. Since Ceres is constantly running and gathering information large servers are required which have a large environmental impact in production and energy use[27]. These servers

have materials, manufacturing, distribution, use phase energy use and disposal considerations. We believe that the energy consumption of the product (both the servers, and the phone) is the most important consideration. Also, as mentioned before, the smartphone our product is integrated with has large environmental impacts with regards to the manufacturing, distribution, and disposal. Even though users would tend to have a smartphone regardless of our application, this is certainly an embodied impact of our product. From this analysis it appears the use phase energy is the most important consideration, with respect to both the smartphone battery life and the server usage.

Stakeholder network

Figure 2 shows the network of the stakeholders. All the stakeholders listed in the design ethnography section are shown. It is important to note that the user also interacts with the company partners (through engaging with incentives and products) and the city planners (by using city services). The boxes show the environmental impacts from each stakeholder and the motivations for engaging with our application. Since our product is encouraging the customers to partake in environmentally conscious behavior, our customers expect our company to be an environmental leader. Our product may also show our customers how our company partners are leading in corporate sustainability.

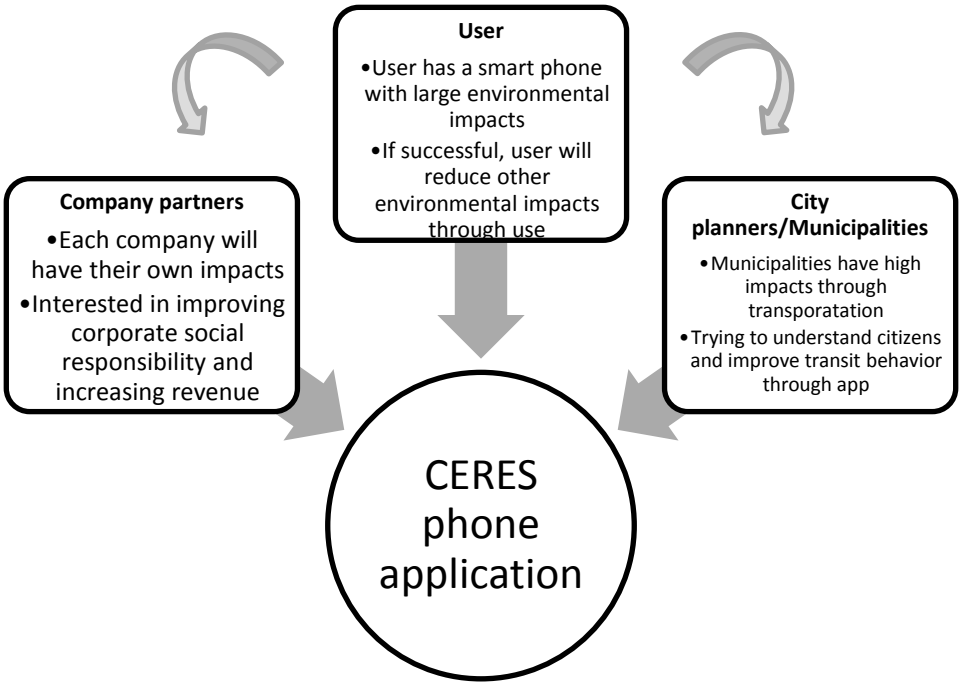

FIGURE 2: STAKEHOLDER DIAGRAM FOR THIS PRODUCT

Quantified Environmental Impact of Transportation Behavior

The baseline of this design is the environmental and social impacts of transportation behavior in the US. Given the fact that this product may eventually be available to smartphone users globally, it is important to consider the changes in global behavior, especially since public transit is more (or less) ubiquitous elsewhere in the world. However, given that our ethnographic data collection is limited to the US, we will present a design with a US frame of reference, cognizant of the fact that these numbers may not be universal.

Nearly 30% of all US GHG emissions are from transportation[8]. Further transportation also generates many regulated criteria air pollutants which have both ecological and human health implications. For the baseline we focused on a few of these pollutants and the GHG emissions. Life cycle transportation data collected by UC-Berkeley was used to understand the relative emissions of each transportation type[23]. This life cycle data is normalized to passenger mile traveled, therefore average ridership of public transit is accounted for in the raw data. Data from the US-Census[22] and the Federal Highway administration[24] was used to understand how Americans currently commute, the respective distances, and the relative usage of buses and rail. Appendix II shows the detailed data. Figure 3 shows the baseline. It is well understood that anthropogenic sources of greenhouse gases have to be mitigated. Other transportation related air pollutants include: nitrogen oxides (NO_x) which can contribute to ground level ozone and adverse respiratory effects, sulfur dioxide (SO_2) which can also cause adverse respiratory effects, particulate matter (PM_{10} are particles between 2.5 and 10 microns) can enter the heart and lungs and have adverse health effects.

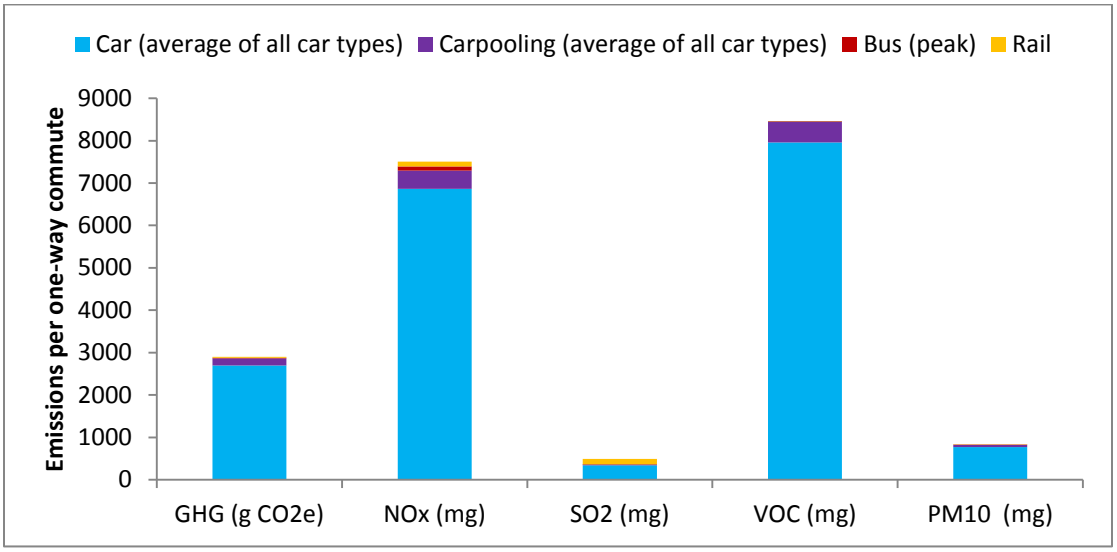

FIGURE 3: US EMISSIONS PER ONE-WAY COMMUTE BY TRANSIT TYPE

A few assumptions were integrated into this data. It is assumed that a negligible amount of commuting occurs during off-peak hours. This is a reasonable assumption as commuting departure time has a normal distribution[28]. Additionally it was assumed that when carpooling occurs there are 2 people in the car, and there is no additional distance. While this may not be strictly true, at this stage our application does not address carpooling, hence it does not currently affect our anticipated improvements from the baseline. The transportation data utilized accounted for the entire life cycle, including the city infrastructure necessary for the transportation. The data used for this analysis was strictly the use-phase of that transportation type. This is because, given our interview with the transportation expert, it is highly unlikely our product will influence infrastructure projects developed by a city; there are too many other influencing factors. Because only the use phase was accounted for, the emissions from biking are zero. Lastly, the authors of the UC-Berkeley study quantified the life cycle of three different car types (pickup truck, sedan, and SUV) and for five different rails (BART, Caltrain, Muni, T, CAHSR) from around the country. These were just averaged and were not weighted by proportion of usage. It should

therefore be noted that the rail data had a very high standard deviation, higher than the average in many instances.

Concept Generation & Selection

Concept generation began with identifying the biggest customer needs. Previously, we have identified a major need for altering social behavior regarding sustainability through increased awareness of exactly what is sustainable while competing. Broadly, we focused on generating an educational tool that will incentivize users to change certain behaviors. Our team took an integrated design approach[29], brainstorming design concepts by looking at the whole system starting from the user and finding products that could be integrated into already existing products. Although integrated design tends to be used in the context of buildings or vehicles, the principle of optimally combining different technologies can be applied to all designs. Similarly, our approach also optimized or reduced materials as described in LiDs design[30]. Combining a new technology into an already existing product efficiently uses resources and is convenient for the user. A functional decomposition, shown in Figure 4, led to categories in which concepts were generated. The first function of the design was deployment, meaning through what tool or medium the information could be distributed through. Appendix 3 lists all generated ideas in this category. Other important functions seen in Figure 4 include the incentive structure, what incentives are used within these structures, how altered user behaviors will be verified, and sources of revenue. These generated concepts are listed in detail in Appendix 3.

Designing to alter user behavior requires providing an incentive to change; a strong incentive structure must be implemented. Three different concepts for incentives were investigated and examined in detail.

The first incentive structure is based on a service called “Gym-Pact”[31]. This service incentivizes users to go to the gym by letting them set a goal for the week. Gym-Pact monetarily rewards users who reach their goal and punishes those that do not. The two important aspects of this structure is that users decide for themselves what their goals are and that users are punished if they do not achieve their goals. As users are most familiar with themselves, setting personal goals that match what they can realistically achieve, rather than attempting to achieve a generic goal, allows a more personalized target that the user can better relate too and thus may be more motivated to achieve. However, using punishment as an incentive discourages many users as illustrated by our ethnographic research. This incentive structure eliminates the need for external advertisers since revenue from the product comes from users failing to meet their goal. A second incentive structure was a simple reward system, meaning that instead of punishing users who do not achieve a goal, users who do are rewarded with some form of incentive, such as money or discounts. Thirdly, as users want to have an increased understanding about sustainability[1,12] we considered a simple educational tool so that users gain a deeper understanding about the importance of sustainability. This structure relies on users motivating themselves to change their behavior based on increased knowledge.

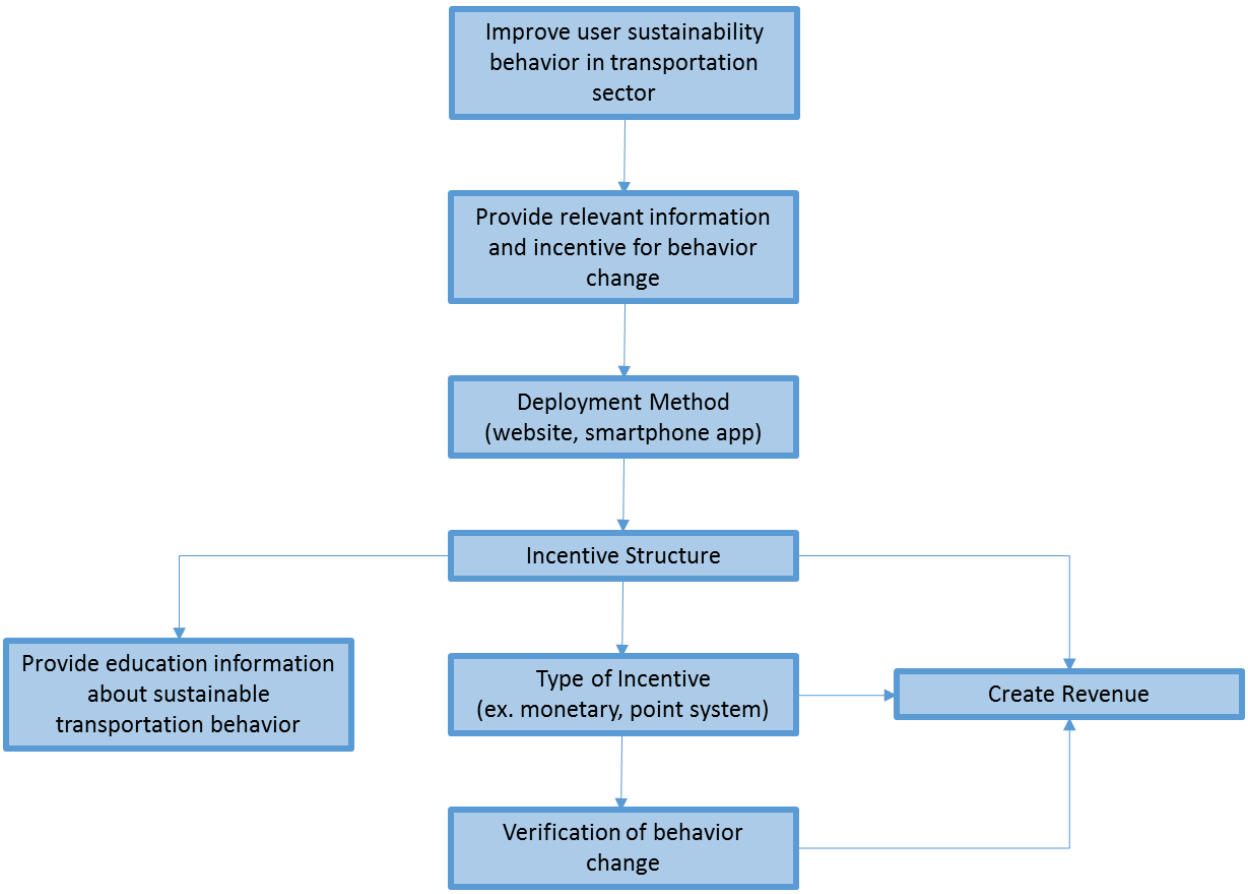

FIGURE 4: FUNCTIONAL DECOMPOSITION

We also established concepts for the verification methods. We chose a few different ways: (1) using the GPS and accelerometer capabilities of the phone to track transportation behaviors (2) users take a picture of their transit receipts (3) we develop a technology, much like the Nike Fuel band, which can attach to the bicycle to track bike transit, (4) use cell towers and Wi-Fi networks to track transportation behaviors. The second and third concept would have to be combined to account for the entirety of transportation behaviors. Even so, this would not account for people who choose to walk to work. Using GPS and accelerometer capabilities does decrease battery life, however we have found that certain algorithms can be used which may reduce this effect[32]. Using the Wi-Fi networks and cell towers has no effect on battery life; however this concept has more limited location accuracy[33].

After establishing ideas for potential concepts, selection process began by establishing which design requirements previously established were most important. Two scoring matrices for two categories were created and used to score each concept. Concepts generated with the two most vital categories of our design, namely incentive structure along with validation of user behavior, were placed into the matrices. Tables 3 and 4 show these two matrices. Two matrices were chosen due to the difference in requirements between the two categories.

TABLE 3: SCORING MATRIX FOR INCENTIVE STRUCTURE

Stakeholder Requirements	Importance Weight Factor (1-10)	Gym-Pact Model	Reward System	Educational Tool
Easy for User to use	9	7	6	8
Top users get the most rewards	6	6	8	0
Informative	6	7	7	8
Advertising space for partner companies	6	6	6	6
Marketing--stylish design	3 (Y=1,N=0)	1	1	1
Collect data on effectiveness of advertising	9	6	6	6
Total		33	34	29
Weighted Total		234	237	213

TABLE 4: SCORING MATRIX FOR VERIFICATION METHOD

Stakeholder Requirements	Importance Weight Factor (1-10)	Accelerometer + GPS	Receipt or Ticket Picture Upload	Device Attached to Bike	Wi-Fi +cell towers
Data Security (based on standard)	6 (Y=1/N=0)	1	1	1	1
Precise Location	9	8	6	9	7
No extreme effect on Smartphone battery	6	7	9	9	8
Ease of use (both user and other stakeholders	9	9	6	7	8
Universally applied (PT and bikes)	3 (Y=1, N=0)	1	0	0	1
Verification technique must be well integrated into smartphone	3	9	9	7	9
Verification Independent of User	6 (Y=1/N=0)	1	0	1	1
Total		36	31	34	35
Weighted Total		237	195	231	225

From these matrices, the alpha design was established. This design consists of using a reward system incentive structure and GPS and accelerometer technology to verify the user's position and hence their transportation mode. The most important requirements for verification were precise location and ease of use for the stakeholders. GPS provides precise signaling, especially in areas that may not have Wi-Fi or cell tower signal. GPS and accelerometers are also standard in smartphones, so it is well integrated and requires no additional soft- or hardware. The major benefit of using a rewards system instead of the Gym-Pact model or a simple educational tool is that top-users are easily identifiable. If a Gym-Pact model were used, it would be easier to determine who accomplished the least rather than the most. Furthermore, if this model were adopted our business would be dependent on users not acting

sustainably and it would depend on users being motivated enough to act sustainably that they are willing to pay money. This requires a high level of external motivation that may be present in health services (i.e. I want to go to the gym to be healthy and I am willing to pay a service to make sure I do) but not in environmentally sustainable behaviors. While focusing on providing the most information through a simple educational tool, users would have to motivate themselves to behave more sustainable. The alpha design will also incorporate all other functional categories listed in Appendix 3.

The Alpha Design

As explained in the previous section, the current alpha design employs an app that uses a reward system to encourage sustainable behavior, and verifies this behavior through GPS and accelerometer found in smartphones. The reward system uses normalized points corresponding to the sustainability of the users' transportation choices. The app will be design to allow users to collect points for sustainable choices in transportation. Using the GPS and accelerometer found in smartphones, the app will track the location and speed of the user to verify their transportation mode, meaning car or bike. Unfortunately, this requires the user to turn on and off the GPS function while traveling. While this may be burdensome, this will ensure the most accurate verification. Additionally, this verification method may not be applicable as Ceres expands to include further sustainability efforts beyond transportation, including home improvements such as LED installation. The GPS function also tends to drain battery quicker than other functions, but this may not be a significant challenge if the user remembers to turn off the GPS function. Based on how sustainable the choice of transportation is and the frequency with which the user uses the app, the rewarded points will reflect the sustainability. This means, that a user who bikes instead of drives or even takes public transportation will receive more points. The users with the most points can receive the most benefits, which potentially includes discounts at stores that Ceres has agreements with. After establishing a strong lead concept in transportation, Ceres has the potential to expand to other areas of sustainability including incentives for reusing grocery bags or improving sustainability at homes through installation of LED lights or energy star appliances.

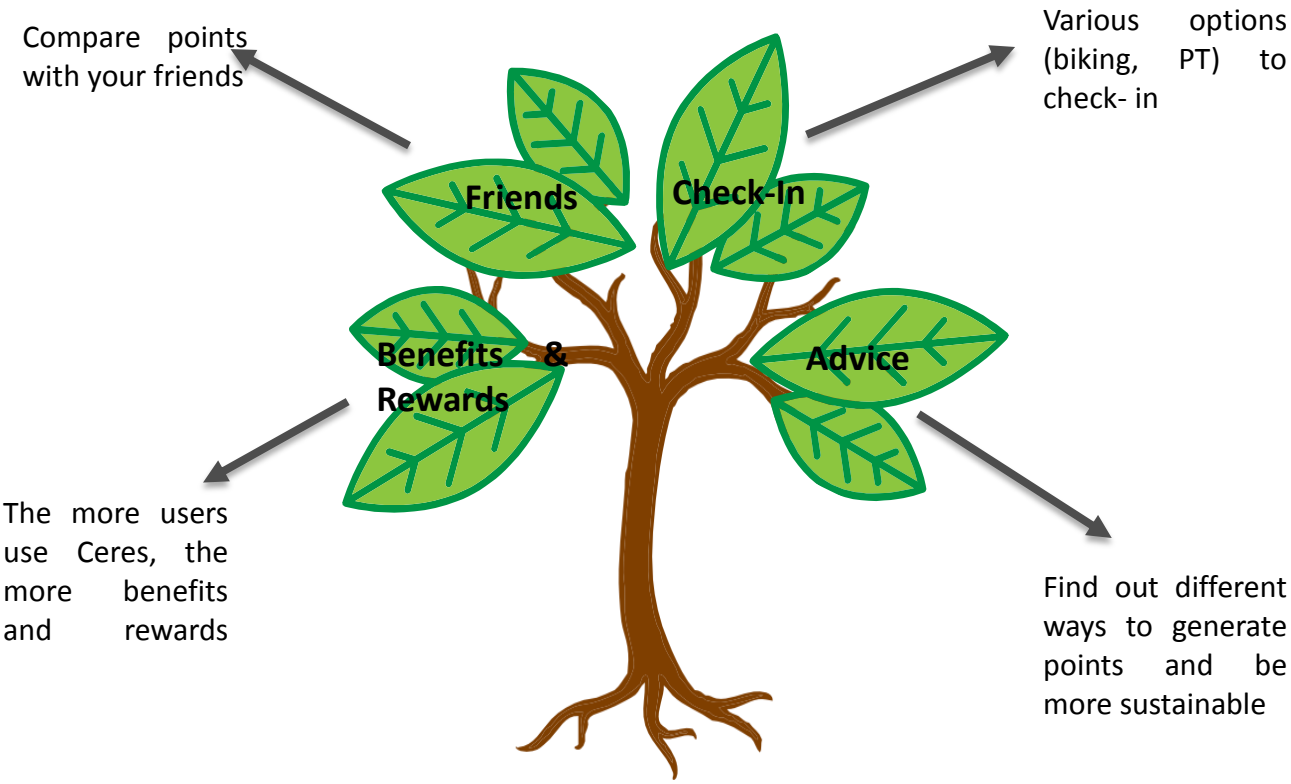

FIGURE 5: GENERAL LAYOUT OF APP

There are four main functions of the product the user can interact with shown in Figure 5. Users can view their current points on all screens. When the user installs the app, Ceres notifies them which of their contacts also use Ceres, so they can connect and be their "friend". Being friends means they can share and compare points, as well as make suggestions to their friends for sustainable ideas. Furthermore, users can choose to post their points or accomplishments on their facebook or twitter, but are not required to. This screen will show the user what their net environmental benefits are (i.e. greenhouse gas abated). The average benefits for their town and their network (friends) will also be displayed on the screen. The check-in functionality will record where they have been and what forms of transportation have been used. Along one side of the screen will be Ceres advice, for instance "Bus route 5A will get you to work in 25 minutes," or "Why not stop by Clown Dog bike shop on your way home for a tune up?" This will incorporate the company-sponsors we hope to gain to increase revenue.

The interface will be simple, with examples shown in figure 6.

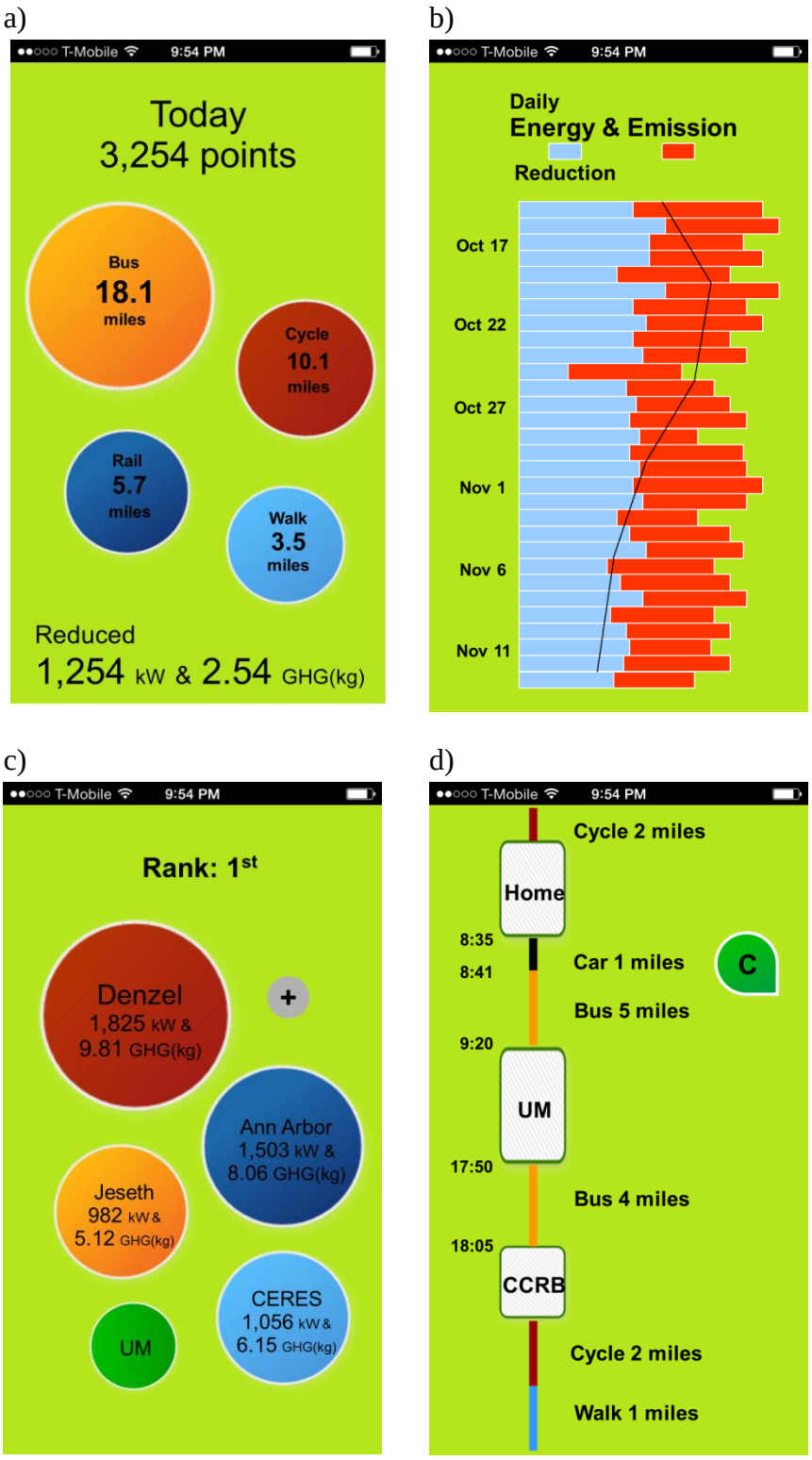

FIGURE 6: USER INTERFACE (A) HOME SCREEN (B) PERSONAL IMPACT SCREEN (C) FRIENDS SCREEN (D) DAILY LOG SCREEN

Environmental Improvement and Uncertainty from Alpha Design

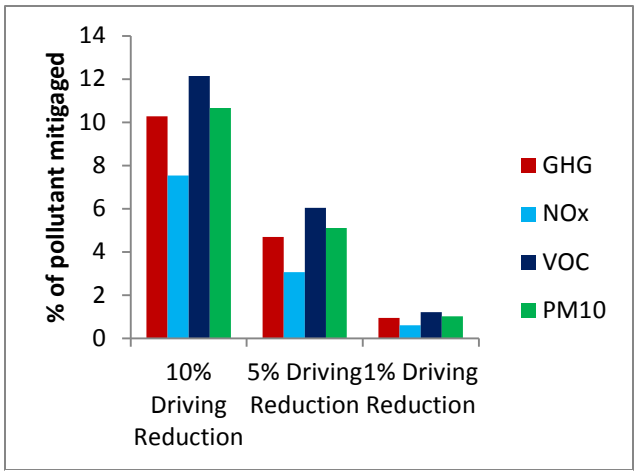

FIGURE 7: PERCENT OF GREENHOUSE GAS AND CRITERIA AIR POLLUTANTS MITIGATED FOR DIFFERENT BEHAVIOR CHANGE SCENARIOS

The environmental improvements from our selected concept depend on whether users engage with the product and whether the change in behavior is long-term. While we are aiming for our users to reduce their driving by 5% at the end of the first year, there is some degree of uncertainty in our ability to achieve this. Therefore we generated three potential scenarios shown in figure 7: the most optimistic, 10% reduction in driving, 5% reduction in driving, and 1% reduction in driving. The detailed data is shown the Appendix II.

There were numerous assumptions that went into generating this data. Users are unlikely to move closer to work to engage in our application, and it is unlikely a public transit route would be as direct as their car ride. Hence, we assumed the bus and the rail would be 10% more out of the way. Any more than that and it is unlikely the user would stop driving. In addition, it was assumed that 80% of people who stopped driving started using public transit and 20% started biking or walking. This seems reasonable since biking and walking is limited by how far people live from their work, their age, how safe they feel biking or walking, and climate.

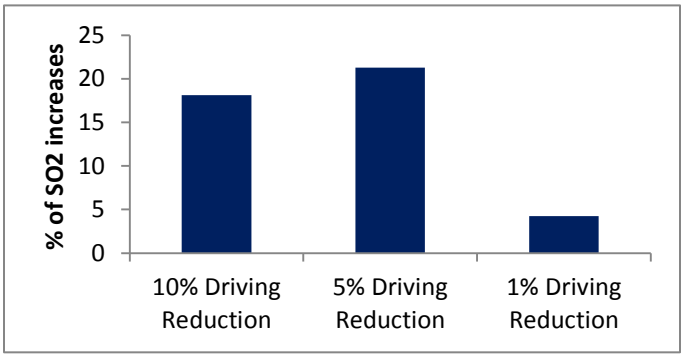

FIGURE 8: SULFUR DIOXIDE INCREASES ASSOCIATED WITH DIFFERENT UPTAKE RATES OF APPLICATION

In general, the percentage of total environmental pollutant mitigated is proportional to the percentage of users who stop driving. This is not true for sulfur dioxide emissions. In fact, due to the high magnitude of sulfur dioxide from rail compared with cars, even though the data is normalized to passenger mile travel, our application has net positive sulfur dioxide emissions (Figure 8). In fact, a 10% reduction in driving causes an 18% increase in SO_2 emissions. It should be noted that transportation is not the most important source of sulfur dioxide emissions, power plants are a more significant source. This is also a pollutant that had a very high standard deviation. It may be assumed that newer forms of rail have much lower SO_2 emissions. This result can inform our point scale. Bus transit should gain more points than rail, and biking or walking should have substantial more points than the other transportation methods.

Feedback on the alpha design

Our feedback was sought in various forms throughout the design process. As reflection is a key step the design process, we interviewed multiple stakeholders at various stages in the design process. After an initial design, we sought feedback from users and did so again after a final alpha design was designed. Observations and research in transportation was done to support the ideas of the alpha design. Finally, a survey was conducted to deepen our understanding of user behaviors and how our design can be changed based on this behavior, shown in Appendix I. We obtained 32 responses to our survey, 7 of which were from the design expo.

Final Concept Description

In general the alpha design was the same as the final design. We received feedback in three areas that we incorporated into the final design.

Providing a Pro-Version

One piece of feedback we got from the course administrators was to have a pro version that gives people more detailed environmental impact information. We originally viewed this as a very niche product for the most extreme environmentalist. Surprisingly, 19% of those surveyed "would keep spreadsheets" on environmental impacts. These users are therefore likely to purchase a pro version. Having this version of the app requires a staff member that is dedicated to assessing, updating, and understanding environmental impacts. We will sell the pro version at $1.99. Assuming 10% of our users purchase this version, this product is a very small percentage of our projected revenue (less than 1%) and therefore will not contribute to profitability of our product. However, having this version available will increase the educational value of our product. It will also promote our reputation beyond that of a "green" company, and towards a company that values quantitative assessments of environmental impacts.

Protecting User Privacy

While in general the interviews we did early on in the process indicated little concern for privacy, survey data is mixed. On average, users do not think the apps they use are private, but they are less likely to use an app because of the privacy policy. There is a discrepancy between what action users take and their survey response. Future ethnographic research may attempt to understand this discrepancy. It seems transparency, in the form of an informative privacy policy, may be an important factor for users to feel comfortable using our app. One user commented on the question regarding a privacy policy saying they may or may not stop using an app "depending on what the app is for." This implies that if users see some benefit from using the app they are more likely to keep it even if they think their private information is being shared. We think the benefit of discounts would be enough for users to agree to the privacy policy.

Nevertheless, our privacy policy will need careful consideration. We will manage the personalized advertising ourselves, not sell the data to other companies. While this may be more costly for us, we will be able to maintain the trust of the user. Furthermore, we will need to store the transportation data of the user to create the personalized advertising. The physical security of the servers will be comparable

to those used by banks. This will also be costly, but is vitally important. Our company policy is that the data we store is owned by the user. Therefore, the users can at any point download and delete the data we have saved on our servers if privacy becomes a concern for the user. In order for this to be a sustainable design, we need a sustained user base, which requires users to trust the Ceres. We believe that with a high level of transparency, users will trust us with their information.

Offering meaningful points

Ceres's reward system rewards users one point per gram of greenhouse gas reduced, so the more effort the user inputs, the more points they receive. The points will be kept in two ways, and both of them will be added to an account in real time. The first one will keep a cumulative record of all the points earned, and can be used to compete with friends as well as review how a user is doing. The second manner, called credits here, will be used for users to know how many points are available to use as discounts.

On special occasions, we will give away extra credits for users. For example, if the Ann Arbor Transportation Authority launches a new route we will give users double the credits if they take this route in the first two weeks. The extra credits are a way we can advertise for our clients, and also a way to engage and retain users. Each discount/benefit will require a certain amount of credits. When users use credits to purchase discounts/benefits we will send a digital coupon for the user to present at the store. We anticipate the smallest benefits to cost 1500 points this is equivalent to about 5 miles on a bike and about 7 miles on a bus. The average person will only need to change their commute one or two days a week in order to start receiving benefits. In summary, the points represent users' achievement, and the credits are a tool for us to benefit and engage our users.

Business Plan Section

Company description

Ceres provides personalized services that help our users behave sustainably free of charge. Instead, we mainly gain our revenue from personalized advertising for our partner/client companies. Our company partners are interested in the personalized advertising we provide and attracting new customers. However, a $1.99 pro-version of Ceres will be available 24 months after the launch of Ceres to satisfy advanced users.

Our market is users interested in saving money. The app will provide active users with discounts from our advertising partners. Current eco-friendly apps focus on simply reducing energy consumption. There are no available apps which reward users who save energy or who engage in any other environmentally friendly behaviors. Our product combines the long-term ecological benefits of sustainable transportation with instant gratification in the form of discounts.

Although we designed with an environmentally conscious customer in mind, our customers are simply those who want to save money. Our customers own smartphones and use apps. Our product provides our customers with additional benefits: information about their environmental impact, information about how they compare with their friends, and information about their travel time, distance and mode. Our customers can gain all the benefits of Ceres for free.

Market analysis

A smartphone application like Ceres has a very broad market, especially when combined with reward system. Specifically, Ceres is in direct competition with energy efficient apps, ecological footprint apps, ecological information apps and other rewarding apps, as well as relevant websites and programs. Most of these programs do not try and reward the user, and therefore we have a competitive advantage. The program we found that does try and reward users (bicycle benefits[19]) has modest benefits to the advertisers. Our product is technology driven and offers personalized advertising.

The smartphone application market in U.S. contains 200 million active devices[34], and about half of them are our potential users who decide their own transportation. Smartphone usage is also rapidly growing in countries like China and India, indicating that our product has the potential for global growth. Finally, with the rising energy cost, increasing impacts of climate changes and deteriorating ecosystems, some users may be more motivated to change their behavior.

There are thousands of apps existing in the market, and about half of them are free[35]. It is a big barrier for Ceres to distinguish itself from them. Besides, sustainability is a concept that is harder to be accepted by the general public than simple labels such as eco-friendly or energy efficient, so we need to let people know the advantages of sustainable behavior against simply eco-friendly or energy saving behaviors.

The last barrier is the privacy issues. Even though most of our surveyed users use apps they do not believe are private, our privacy policy will need careful consideration. We will manage the personalized advertising ourselves instead of selling the data to other companies. While this may be more costly for us, we will be able to maintain the trust of the user. Furthermore, we will need to store the

transportation data of the user to create the personalized advertising. The physical security of the servers will be comparable to those used by banks. This will also be costly, but is vitally important. Our company policy is that the data we store is owned by the user. Therefore, the users can at any point download and delete the data we have saved on our servers if privacy becomes a concern for the user. In order for this to be a sustainable design, we need a sustained user base, which requires users to trust the Ceres. We believe that with a high level of transparency, users will trust us with their information. The privacy policy still needs lawyer consultation and greater user input.

The barriers above are difficult to overcome, but they also create opportunities for Ceres in the competition. There are only few apps which focus on sustainability and these are provided by non-profit organizations. None of them are rewarding users for their good behavior. Ceres will use advertisements and users' information to generate profit to cover all the expenses and properly handle users' privacies. However, the pros come with cons; our financial structure is much more vulnerable compared with competitors since we need more partners/clients to support us.

People are used to using apps for free, and seldom or never pay for an app. As a result, we are going to be a free app, but we have a pro-version that is going to cost $1.99. Although the pro-version will still maintain the same reward system, it has detailed information regarding transportation environmental impact. Nevertheless, the projected revenue from the pro version is less than 1% of our total revenue, therefore, the payment from our partner/client companies are still the main financial contribution to Ceres.

Product Description

Ceres does not need users to check-in or manually upload data. It will automatically use GPS and accelerometer technology to verify users' behaviors such as cycling or taking public transportation, and reward points proportional to the environmental impact. The points allow users to receive exclusive benefits or discounts from firms nationwide, which are very attractive to users since they do not need to pay for Ceres. For our busy customer, our product makes getting benefits easy, all while helping the environment. Besides this, users can compete and share their progress with friends or groups that they select from their contacts, which also provides a means to socially connect.

On the other hand, by analyzing users' habits, Ceres provides personalized advice regarding their behaviors. For instance, our product will tell the user that the distance, weather and traffic conditions from his/her home to school is suitable for biking today. Or, Ceres will tell the user he/she has cycled regularly for six months and there is a bike shop on Plymouth road offering Ceres users free bike checks. Therefore, users will not only know their current achievement, but also understand potential for future improvement in a simple and personalized way. Once new products, services and policies come out, we will also inform our user how these fit into their current life. For example, you can take a new bus route that goes directly from your home to your workplace instead of driving. Also, knowing user commuting routes and transportation habits, Ceres will be able to recommend stores, products and services for users' convenience. All the features are laid out within 4 smartphone screens with a simple and easy user interface.

Ceres is a smartphone application that still needs programmers to become a useable product. So far we have decided the configuration of Ceres, but we are still working on the detail of the reward system and the programing requirements. A fair reward system will ensure people are really making this planet more sustainable while competing with friends and gaining benefits. There are two major programming requirements we are focusing on, namely the privacy issues and the device battery usage issues. We are going to protect users' private information by processing this data internally instead of directed give this information to our partner/client companies. Also, applying new technologies[32,36] will enhance the battery life.

Marketing and Sales Strategy

Market penetration strategy

We will begin by marketing to customers who already engage in sustainable transportation (advertising on buses and in bike shops). These users will be most likely to be early adopters of our product because they are likely to see easy benefits. Once customers are saving money, we hope that we can expand by word of mouth to other users; we will expand our communication strategy from this point as explained later.

There is some circular logic in the way our marketing plan works: we need users to prove to corporations that partnering with us is profitable, and we need corporations willing to give out discounts to attract users. To mitigate this effect in the early stages, we will attract companies with a sliding scale. Companies which choose to partner with us will pay much less to advertise in the first year of partnership. We will offer companies a thousand impressions at $1.00 plus a minimum of $100 equivalents in discounts. This is compared to an average advertising cost of $2.85 per thousand impressions for iPhone apps[37]. By phase two the cost per thousand impressions will increase to $5.00 because we will be able to prove to our partners the efficacy of our advertising methods. We hope this deal will allow for early advertisers.

We expect to be at negative profits for the first two phases, and will require investors to sustain the product. By the end of phase 1, we hope to have 25 advertisers purchasing $1000 dollars' worth of advertising. Appendix IV shows the project costs and revenue.

Communication strategy

We will begin by marketing to customers who already engage in sustainable transportation (print advertising on buses and in bike shops) in Ann Arbor. These users will be most likely to be early adopters of our product because they are likely to see easy benefits. Once customers are saving money, we hope that we can expand by word of mouth to other users. We will promote the product with a social media campaign. Because we are starting in Ann Arbor it will be relatively easy for us to advertise in this fashion. When the product is ready for deployment we will hold a promotional event and invite relevant press to continue to spread the word about our product.

Channels of distribution strategy

We will initially deploy our product as an iPhone application, shortly afterwards we will expand to Android interfaces. Within the year we aim to be integrated with Windows phone interfaces as well. This order was chosen since the hardware (accelerometer and GPS) in iPhones is universal, facilitating this as an initial distribution strategy.

A growth strategy

In the prototyping phase, we will have the three founders and one programmer and interface designer working on the team. The second year we will need to hire advertising personnel to help manage advertising sales and logistics. Eventually a team of 15 employees will be needed: 3 administrators, 4 software engineers, 2 interface designers, 1 LCA expert in charge of developing and updating the impact categories in the pro version, and a team of 5 people selling and managing advertising.

We will pursue a horizontal growth strategy. Year 1 we will focus on Ann Arbor users, year 2 we will expand to other cities: Portland, Austin, and the Bay area. Year 3 we will begin pursuing other cities and other environmentally sustainable behaviors (e.g. saving home energy, recycling, etc).

Funds Needed

To estimate the funds required to start up the company, we investigated other smartphone apps that use similar advertising campaigns as we plan to determine an approximate our estimated funding[38]. For launching and the first phase of starting up, between $75,000 and $200,000 will be required. This will have to come from personal funds, family and friends as well as investors. The expectations for this year will be to develop and program a prototype. The major expenses will be the salary of the founders and programmer (~$30 k/year each). The programmer will be expected to receive a slightly larger salary than the founders. Other expenses will be the technology ($10K), office space and legal (<1% stake of company). The first stage will be expected to last less than year before the second phase will begin. The second phase will require major funding as marketing will be a large investment, along with increased personnel. Approximately $750,000 will be required for phase 2. User growth will be demonstrated in this phase. Salaries ($50-90K) will be increased and used to attract increased personnel. Nearly $50K can be expected for legal fees, which is very important for a tech company. Overhead costs will use up the remaining funds. Beyond Phase 2, profitability can be expected to sustain and fund the company forward. Phase 3+ will once again see an increase in personnel with the final yearly expenses ranging from $1-5 million, depending on the team-size. In phase 3 we anticipate launching the pro version of the app. The more expansive the company becomes, meaning the number of cities the company expands into, the higher the required number of personnel. Another factor that will affect technological costs as well as team size is the introduction of multiple sustainable efforts, where different modes of verification will be necessary. Figures shown in appendix IV show three possible breakdowns: a conservative, middle, and an optimistic estimation. A more detailed breakdown is shown in Appendix IV.

Additional Reflections on Project Outcome

Why is the project likely consistent with an eco-efficient or sustainable design?

Ceres should be considered an example of sustainable design because it can transform the way people transport themselves. Ceres will provide a means for socializing around environmental sustainability.

There is a risk of becoming a victim of success as encouraging people to use public transit will lead to higher emissions (specifically sulfur dioxide) per person than vehicles. However, this will still be beneficial because if everyone used public transit there would be fewer requirements for roads and land use.

Ceres does have the potential of being used differently than expected. Particularly with computers and smartphones, people often figure out ways to cheat the system and get rewards that they have not rightfully earned. While economically we will still be profitable, the sustainability and social benefits of user behavior will not be seen.

Design Critique

Our product has a clear economic benefit. All the users we talked to seemed very interested in the product. Our product capitalizes on the desire to save money, which is essentially universal. However there are still many deficiencies. For instance, we have never talked to a business about advertising. So we potentially have an unrealistic understanding of what they would require to partner with us.

As none of us have significant programming experience, it is difficult for us to know whether it is possible to program all of the design, especially analyzing personal data to produce personalized advertisement. We don't have a good understanding of how the GPS and accelerometers work in all the phones we are planning on interfacing with.

Future modifications will most likely have to be done after receiving feedback from programmers to understand the difficulty of creating Ceres. Other issues with the device may only come to light after users begin using Ceres. These bugs will then be fixed and included in future updates.

Recommendations

Recommendations for the future are based on the weakness we uncovered with this project. First, talking with local businesses to understand their commitment to the project is vital. Ceres will not be successful without these partnerships. Secondly, we recommend having a lead programmer attempt to program and analyze the difficulties with programming the smartphone app. This will provide insights into what will and will not function with the app. From this information, changes will need to be made. If there are major issues, reflecting back to the generated concepts will aid in reworking the areas that will become an issue while programming. We also need a better understanding of the accelerometer and GPS technology we will be relying on. Third consult with a lawyer to obtain a better understanding of potential issues regarding privacy (e.g. litigation risks), incorporating Ceres, and obtaining intellectual property.

Additional Reflections on Project Outcome

We should gain a better understanding of how Ceres will function in other cities. More consideration should be paid to cities with multi-modal transportation, and how Ceres will interface with these transportation modes.

We need more realistic financial projections: what is the willingness to pay for mobile advertising, what does our projected overhead consist of, how much should we expect to pay in taxes, what are the competitive salaries and benefits for our employees, how much will data storage cost?

In addition to the battery usage issue, we should also consider the data issue. Our servers need to exchange data with users' smartphone to verify their behavior, and most of the time there will be not Wi-Fi connection around our users since they are traveling. Which suggests we need to use their cellular data, and it may be an issue for those who do not have unlimited data plan.

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Appendix I: Design Ethnography Details

[redacted] a first year graduate school student that studies public health. She does not consider herself an environmentally conscious person.

1) Why you think you are not eco-friendly?
I use disposable tableware in the cafeteria, and I never brought my own bag when doing grocery shopping.

2) Are you a prodigal person?
No, I use as less energy as possible at home, since it will save me money.

3) If you can have benefit from being eco-friendly will it motivate you ?
Of course, I will do as much effort as possible as long as it won't bother me.

4) How about letting your friends know you are green?
No, that does not count. That will be fun, but I don't think that will be a motivation.

5) What about giving you coupons for being green?
That will be awesome, but you can also like letting me download exclusive musics or apps. That will be cool, if you have music from popular artist that only available for people being green.

6) Do you worry about privacy issues?
I care about it. However, so far there is nothing bothering me, and I am still using Facebook and other smartphone apps.

7) I explained what Ceres does, and asked if she is willing to use it.
Of course I will use it, but does it make phones run out of battery sooner? If not I will turn it on when I start my day, since I want to earn as many points as I could. I will love to try the carpool function, but I am afraid of meeting bad people.

8) Thank you for helping, does any kind of coupon especially attracting you?
I want to get a MacBook, if there there is Apple coupon I believe people will be crazy about this app.

9) Would you be interested in engaging with this product?

Yes, I will, since it has points that reward users with discounts. I would like to do some effort for our planet though I am not an active sustainable person. Besides, I always give any smartphone app that is free and easy to use a chance.

10) Do you think you are more likely to change your behavior through being rewarded or being punished?

I do not want to be punished in any means, although from experience punished systems may help me do better in any activity. I consider all apps as assistance to my life, so I prefer the purely rewarded systems. However, it will be interesting if you can let me know what punishments I am going to suffer if an app that I am using is having a punishment system instead of current system.

10) Do you have concerns about your privacy when you engage with social media or apps? Do you avoid apps because you think they may violate your privacy?

So far, I never think about it, but some day in the future, I may. If I am married or becoming somebody, the privacy problem could be an issue. Just do not make it accessible by everyone, otherwise, currently, I can live with it.

[redacted] is a second year graduate student that studies environmental and water resources engineering. She does not think she is an environmentally conscious person.

1) Why you think you are not eco-friendly?
I never recycle, since it is bothersome. But if I am buying new house appliance I will consider one that is eco-friendly. I just do not want to change my life so I can be eco-friendly. I will not make this world a different place, so I just do what I always did.

2) If you can have benefit from being eco-friendly will it motivate you?
Of course, no one wants to deteriorate our planet on purpose. I am lazy, but if there are benefits I will become eco-friendly.

3) How about letting your friends know you are green?
Well, It will be cool if my friend knows I am green. However, it will not exactly be a motivation.

4) What about giving you coupons for being green?
Wow, that will work. You know, girls love any kind of discounts even if it rock

5) Do you worry about privacy issues?
I do not worry at all. If someone wants to know about my privacy he/she will eventually find a way to get it.

6) I explained what Ceres does, and asked if she is willing to use it.
I will like to earn points, but I probably will not use the competition and status thing. Besides, educate people is a good function, like I don't exactly know what should be recycled.

7) Thank you for helping, does any kind of coupon especially attracting you?
I prefer discounts of restaurants and grocery stores, since I went these places frequently. I don't want to go somewhere distant in order to use coupons.

8) Would you be interested in engaging with this product? (you can be very honest)

I will be happy to try it, even if it needs to set up an account. Since I have long been eager to do effort to make our planet sustainable, I am willing to try them if they are free. It's a bit pity that you are now only focusing on transportation, but still if it's good you can always make extensions. I am going to keep the app if it meets my expectation, but if it is complicated to use I will delete it.

9) Do you think that you are more likely to change your behavior (any behavior, like going to the gym for instance) through being rewarded (coupons/cash) or being punished (have to pay a fee)?

I prefer the rewarded system, and I don't like the punished system even if it is together with rewarded system(You meet the requirement then your will be rewarded, otherwise, you will be punished.). Because if the punished system is not a real big deal then I tend to ignore it after a while, like an alarm app I once downloaded, you must play it hard when it ring or it will post something funny on your social app page. If the punishment is too serious, mostly they are not, I consider it bringing me an extra stress.

10) Do you have concerns about you privacy when you engage with social media or apps? Do you avoid apps because you think they may violate your privacy?

I do not think privacy is a concern, and I never hesitate to use any app due to this reason. These days, our personal profile already been known by numerous commercial organizations, so I am fine with it as long as they are not opening these data to the public.

[redacted] is a graduate student at MIT. She does not own a car, using bike and public transportation. Living close to her work/campus, these modes are "fast and flexible" for her to use. She brings her own bags to the store, citing less waste as her incentive to do such. Additionally, at least one of the grocery stores she goes to has a promotion for bring reusable bags. Below are responses to interview questions.

1) What types of apps do you use?
Mail, Calendar, Twitter, Facebook most often. Solitaire, OkCupid, Weather Channel some. Does my alarm count? MIT mobile app a lot too, to check bus times and look at the map. Also, my camera.

2) How many apps do you use regularly?
the ones above. So like 4?

Where do you use apps?
Everywhere. In class and seminar a lot when I'm bored. Sometimes when I'm walking places. I try not to when I have something better to do or am at home.

3) How do you package your bags at the grocery store?
Usually I try to bring my own bag. If I can, I usually check myself out and thus pack my own bag.

Why do you choose to do this?
Less waste. If I am biking, putting things in my backpack makes more sense cause it's easier to balance.

4) Does the store provide packaging for groceries free of charge? Yes.

5) Does your grocery store have any promos for bring your own bags?
Whole foods does, Shaw's doesn't. I go to both depending on what I need and how lazy I'm being.

6) How do you get to work/school everyday?
Normally I bike, but sometimes I walk or take a campus shuttle.

Why do you choose this mode of transportation? Fast and flexible.

7) How long does it take you get to work?
10min, maybe less.

8) If you use multiple methods to get to work/school, explain when you use which?
If I have something heavy or bulky I use the bus. If it is super cold or rainy, too. If I want to go somewhere else straight from the department, I'll sometimes walk.

9) Do you use a different mode of transportation to go other places (restaurants, friends places, etc.)?
I will use public transportation to go to a lot of places like Boston or Sommerville, especially if I'm going to drink or meet other people socially. MIT also has a late ride shuttle that I take if it's convenient in location and time.

10) When asked about what she thought of our alpha design and how she feels about rewards versus punishment:
I think the app idea is cool and it is something I might use: in the past I have made checklists for myself to remind myself to do things like work-out, I definitely think I would feel incentivized to do sustainable things for the sake of such an app. I don't like the idea of having to pay money if I don't make my goals. Sometimes things happen in life and that would just annoy me. I don't know about other users, though.

11) Privacy concerns:
I probably wouldn't care much about data being shared. Although, one of the thing things that creeped me out about foursquare is that I went to the grad student bar my first year and when I start talking to this stranger he asks if I'm from Ann Arbor, MI. Surprised, I'm like yeah. He explained that he downloaded some app that apparently pulls data from things like FourSquare and puts it all together.

[redacted] who works in Michigan's School of Information, works a lot with technology including working as a Director of Infrastructure on programs, as well as an App Programmer. Although he uses a lot of apps, he seems to do things (such as plastic bag use and transportation) in the most convenient and quickest way.

1) What types of apps do you use?
Communication and organization.

2) How many apps do you use regularly? 9

3) How do you package your bags at the grocery store?
As many items per bag, and then 3 bags around it for safety.

4) Why do you choose to do this?
No idea, I always have

5) Does the store provide packaging for groceries free of charge?
Yes

6) Does your grocery store have any promos for bring your own bags?
Yes

7) How do you get to work/school everyday?
Walk/Drive

8) Why do you choose this mode of transportation?
What is quicker

9) How long does it take you get to work?
Either 1 min or 15 min

10) If you use multiple methods to get to work/school, explain when you use which?
It depends on which office I go to

11) Do you use a different mode of transportation to go other places (restaurants, friends places, etc.)?
No

[redacted] is a mechanical engineer living and working in Houston, Texas. She is 24 years old and graduated from college in 2012. She works at a company that services and runs natural gas and coal fired power plants. When moving to Houston she chose to live somewhere as central as possible (within her means) so that she may occasionally bike; however Houston is not as pedestrian and bike friendly of a city as she would prefer.

1) Do you use a smartphone? Yep!

2) Do you use smartphone apps? Yes.

If so, what types of apps do you use? Mainly the ones that come with it (map, music, text, phone, etc.) but I also have some additional apps (facebook, news, games, podcast)

Why do you like the apps you use? because they help me pass the time when I am bored.

Where do you use apps? Everywhere except the shower and pool.

3) How do you get to work everyday? car

Why do you choose this mode of transportation? Cannot walk, ride bike, or use public transport.

4) How long does it take you get to work? 30 mins

5) When asked about interest in our product:

I would (use) the app (if it) was free. If the app wasn't free, I would have to research it more to see how much I would be gaining from using it (besides of course feeling good about being environmentally friendly.)

6) Do you think that you are more likely to change your behavior (any behavior, like going to the gym for instance) through being rewarded (coupons/cash) or being punished (have to pay a fee)?

I think rewards are more motivating. I think avoiding paying a fee is also motivating, but it will likely make me have a negative attitude to whatever is enforcing the punishment.

7) Do you have concerns about you privacy when you engage with social media or apps? Do you avoid apps because you think they may violate your privacy?

I do avoid them if I think they will post to facebook or twitter. If I can turn that feature off, then I am ok.

[redacted] is a 24 year old PhD student at the University of California, Berkeley. She is studying transportation engineering related to public transit.

1) Do you use a smartphone? Yes

2) Do you use smartphone apps? Yes.

If so, what types of apps do you use? a variety of apps... news, a few games, music, etc

Why do you like the apps you use? entertainment, informative, easy to use

Where do you use apps? work, home, commute, basically everywhere

3) How do you package your bags at the grocery store? I use reuseable bags

Why do you choose to do this? The county does let the grocery stores use plastic bags. But I would use reusable ones anyway because its better for the environment!

4) How do you get to work everyday? public transit!

Why do you choose this mode of transportation? I dont want to drive my car in rush hour. also I don't want to pay for parking. I have thought about biking, but it's kind of far and I think it would be hard to motivate myself to go home, knowing that i had to bike uphill at the end of the day

5) How long does it take you get to work? 30 mins

[redacted] also served as an "expert" talked to about transportation practices and data collection.

1) What do you think about this idea?

I think it sounds like a great idea. Like I said before, I am still confused about how the rewards would work for public transit. Yes, here in the Bay Area, BART is run by different people than the bus system. The bus system in East Bay is also different from the bus system in SF. But you can use a clipper card for all three of these places. So I think the idea is great, but it may take some work to get all of the agencies to be happy. Also, perhaps in other cities, the heavy rail and buses would be run by the same agency? I am not sure about this.

2) How do city planners and public transportation authorities decide how/where to expand?

A lot of it obviously has to do with money. Taxes collected in Berkeley obviously don't go toward improvements in SF. While I am not sure of the exact process, I know there is a lot of planning work that happens before a project can start. Someone must evaluate all of the alternatives and decide what is best. There is a long list of projects that need help but obviously not enough money to go around. Once

a project is funded, someone has to complete the EIR to see which alternative for the project is the best. But when it comes to just having a certain amount of money, and how they decide which of the projects to fund, I am not sure about that. Sound more political than transportation engineering to me.

3) How do they get the data they use for modeling/ planning?

Traffic Counts! There are actually companies who all they do is collect traffic data for transportation engineers/planners. This is the data in the rawest form. We also get data from our clients (like the cities that we work for). Their data was probably at some point also from traffic count vendors but they may have collected it a few years ago and now just have models to work from.

4) How do they get cycling data and plan bike routes?

I think this is very different everywhere in the country. I know there are places that already track cycle routes with smartphones. Some apps already exist that let you pick which mode of transport you are using and then the GPS in your phone records the route. The traffic count vendors can also collect bike/ped counts at intersections or along roadways if that is required for a project. I am not exactly sure how they pick the bike route. I am sure it is a combination of public involvement, studies by consulting firms, and just knowledge of the towns' behavior by the planners.

[redacted] is a 24 year old PhD student in Mechanical Engineering here at the University of Michigan. He is studying design science. He was one of the people I spoke to for assignment 1, he doesn't think very much about his home energy use and was part of the inspiration for this application. He does not have a car.

1) Do you use a smartphone? Yes

2) Do you use smartphone apps? Yes.

> I have a mix of games and productivity apps. I really enjoy the apps that are simple to use and make my life easier or add some benefit with minimal effort. I love my Bank of America app because it lets me post checks remotely. I love my simpsons game because it's fun. I also like adding a lot of apps and then just keeping the best ones. I essentially use apps everywhere.

3) How do you package your bags at the grocery store?
Use reusable bags when I remember. Although when I go to the grocery store from work I have to use plastic bags.

4) How do you get to work everyday?
I walk and take the bus. It's the most convenient way to get there and I don't have many other options. It takes me 30 minutes to get to work.

5) When asked about interest in our product:

Level of engagement with the product would be proportional to the discounts available as well as how much data actually goes into it. I don't think I would work too hard for a whole month to get a $1 discount on a light bulb. However, if the app was mostly self-sufficient, and didn't require excessive use input, then I would be more likely to use it. I would also use it more if it provided me with a lot of cool data/graphics related to my environmental impact; it needs to be enough to determine if behavior change has an effect on environmental impact.

6) Do you think that you are more likely to change your behavior (any behavior, like going to the gym for instance) through being rewarded (coupons/cash) or being punished (have to pay a fee)?

I would change behavior if I was going to be punished, but I would never voluntarily sign up to be punished. The rewards are tricky, because usually rewards aren't enough to change behavior, they are usually just enough to add a bit to your behavior (like submitting Coke codes). I don't drink more coke, but I will do a bit of work for some reward.

7) Do you have concerns about you privacy when you engage with social media or apps? Do you avoid apps because you think they may violate your privacy?

I'm not too concerned, but I should be. If I'm just downloading an app for fun, and it asks me for facebook login or something, then I will cancel the download. I don't like that every app has to be connected to everything else.

Survey data

Ceres Smartphone app

How many actions per week do you take which you think are environmentally sustainable?

- none
- 1-2
- 3-4
- 5 or more

Are you interested in learning about your environmental impacts

1 2 3 4 5

Yes, if I could I would keep spreadsheets ◯ ◯ ◯ ◯ ◯ No, I don't really care

Are you more likely to change your habits if you are being punished (have to pay) or being rewarded (coupons, cash)?

- Punished
- Rewarded

If you use apps, how private do you think current apps you use are?
if you don't use apps, feel free to skip this question

1 2 3 4 5

Very Private ◯ ◯ ◯ ◯ ◯ No privacy

Would the privacy policy on an app change whether or not you use it?

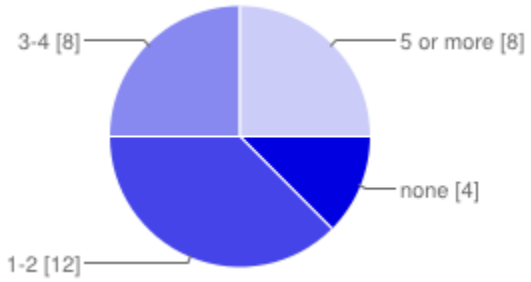
- Yes
- No
- Other:

Feel free to leave us comments/feedback on our project

Submit

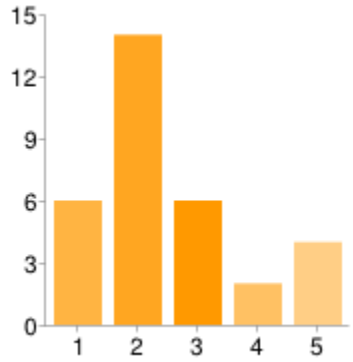
Never submit passwords through Google Forms.

How many actions per week do you take which you think are environmentally sustainable?



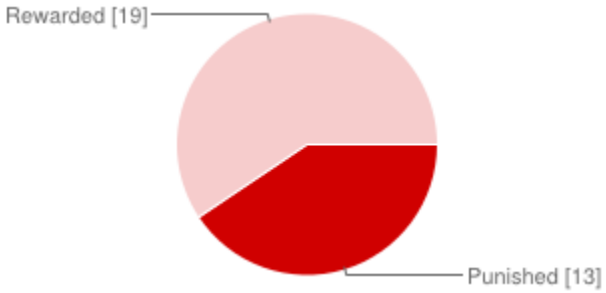
none	**4**	13%
1-2	**12**	38%
3-4	**8**	25%
5 or more	**8**	25%

Are you interested in learning about your environmental impacts



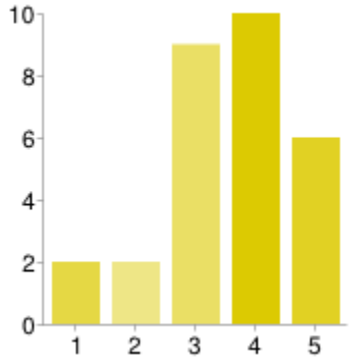
1	**6**	19%
2	**14**	44%
3	**6**	19%
4	**2**	6%
5	**4**	13%

Are you more likely to change your habits if you are being punished (have to pay) or being rewarded (coupons, cash)?



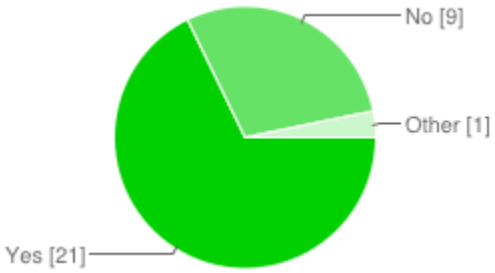
Punished	**13**	41%
Rewarded	**19**	59%

If you use apps, how private do you think current apps you use are?



1	**2**	7%
2	**2**	7%
3	**9**	31%
4	**10**	34%
5	**6**	21%

Would the privacy policy on an app change whether or not you use it?



Yes	**21**	68%
No	**9**	29%
Other	**1**	3%

Feel free to leave us comments/feedback on our project

Great idea, i think i would have this app for fun.

Appendix II: Detailed Environmental Impact Data

Status Quo:

	Impact Category	Amount	Proportion of people	Miles per commute	Total Impact	impact units
Car (average of all car types)	GHG (g CO2e/pmt)	280	0.764	12.6	2695.392	GHG (g CO2e)
	NOx (mg/pmt)	713.3333			6866.832	NOx (mg)
	SO2 (mg/PMT)	35.33333			340.1328	SO2 (mg)
	VOC (mg/PMT)	826.6667			7957.824	VOC (mg)
	PM10 (mg/PMT)	80.33333			773.3208	PM10 (mg)
Carpooling (average of all car types)	GHG (g CO2e/pmt)	140	0.096	12.6	169.344	GHG (g CO2e)
	NOx (mg/pmt)	356.6667			431.424	NOx (mg)
	SO2 (mg/PMT)	17.66667			21.3696	SO2 (mg)
	VOC (mg/PMT)	413.3333			499.968	VOC (mg)
	PM10 (mg/PMT)	40.16667			48.5856	PM10 (mg)
Bus (off peak)	GHG (g CO2e/pmt)	490	0 (assume commutes happen during peak hours)			
	NOx (mg/pmt)	4000				
	SO2 (mg/PMT)	150				
	VOC (mg/PMT)	140				
	PM10 (mg/PMT)	160				
Bus (peak)	GHG (g CO2e/pmt)	61	0.01975	9.4	11.32465	GHG (g CO2e)
	NOx (mg/pmt)	500			92.825	NOx (mg)
	SO2 (mg/PMT)	18			3.3417	SO2 (mg)
	VOC (mg/PMT)	17			3.15605	VOC (mg)
	PM10 (mg/PMT)	20			3.713	PM10 (mg)
Rail	GHG (g CO2e/pmt)	80	0.0279	12.2	27.2304	GHG (g CO2e)
	NOx (mg/pmt)	327.8			111.5766	NOx (mg)
	SO2 (mg/PMT)	368.2			125.3279	SO2 (mg)
	VOC (mg/PMT)	18.32			6.235762	VOC (mg)
	PM10 (mg/PMT)	11.46			3.900755	PM10 (mg)

Biking	GHG (g CO2e/pmt)	0	0.006	1.1	0	GHG (g CO2e)
	NOx (mg/pmt)	0			0	NOx (mg)
	SO2 (mg/PMT)	0			0	SO2 (mg)
	VOC (mg/PMT)	0			0	VOC (mg)
	PM10 (mg/PMT)	0			0	PM10 (mg)

10% reduction in driving:

	Impact Category	Amount	Proportion of people	Miles per commute	Total Impact	Total Impact Units
Car (average of all car types)	GHG (g CO2e/pmt)	280	-0.1	12.6	-352.8	GHG (g CO2e)
	NOx (mg/pmt)	713.3333			-898.8	NOx (mg)
	SO2 (mg/PMT)	35.33333			-44.52	SO2 (mg)
	VOC (mg/PMT)	826.6667			-1041.6	VOC (mg)
	PM10 (mg/PMT)	80.33333			-101.22	PM10 (mg)
Carpooling (average of all car types)	GHG (g CO2e/pmt)	140	0	12.6	0	GHG (g CO2e)
	NOx (mg/pmt)	356.6667			0	NOx (mg)
	SO2 (mg/PMT)	17.66667			0	SO2 (mg)
	VOC (mg/PMT)	413.3333			0	VOC (mg)
	PM10 (mg/PMT)	40.16667			0	PM10 (mg)
Bus (off peak)	GHG (g CO2e/pmt)	490	0 (assume commutes happen during peak hours)			
	NOx (mg/pmt)	4000				
	SO2 (mg/PMT)	150				
	VOC (mg/PMT)	140				
	PM10 (mg/PMT)	160				
Bus (peak)	GHG (g CO2e/pmt)	61	0.024	13.86	20.29104	GHG (g CO2e)
	NOx (mg/pmt)	500			166.32	NOx (mg)
	SO2 (mg/PMT)	18			5.98752	SO2 (mg)
	VOC (mg/PMT)	17			5.65488	VOC (mg)
	PM10 (mg/PMT)	20			6.6528	PM10 (mg)
Rail	GHG (g CO2e/pmt)	80	0.036	13.86	27.2304	GHG (g CO2e)
	NOx (mg/pmt)	327.8			111.5766	NOx (mg)
	SO2 (mg/PMT)	368.2			125.3279	SO2 (mg)
	VOC (mg/PMT)	18.32			6.235762	VOC (mg)
	PM10 (mg/PMT)	11.46			3.900755	PM10 (mg)
Biking	GHG (g CO2e/pmt)	0	0.04	12.6	0	GHG (g CO2e)
	NOx (mg/pmt)	0			0	NOx (mg)

	SO2 (mg/PMT)	0		0	SO2 (mg)
	VOC (mg/PMT)	0		0	VOC (mg)
	PM10 (mg/PMT)	0		0	PM10 (mg)

5% reduction in driving:

	Impact Category	Amount	Proportion of people	Miles per commute	Total Impact	Total Impact Units
Car (average of all car types)	GHG (g CO2e/pmt)	280	-0.05	12.6	-176.4	GHG (g CO2e)
	NOx (mg/pmt)	713.3333			-449.4	NOx (mg)
	SO2 (mg/PMT)	35.33333			-22.26	SO2 (mg)
	VOC (mg/PMT)	826.6667			-520.8	VOC (mg)
	PM10 (mg/PMT)	80.33333			-50.61	PM10 (mg)
Carpooling (average of all car types)	GHG (g CO2e/pmt)	140	0	12.6	0	GHG (g CO2e)
	NOx (mg/pmt)	356.6667			0	NOx (mg)
	SO2 (mg/PMT)	17.66667			0	SO2 (mg)
	VOC (mg/PMT)	413.3333			0	VOC (mg)
	PM10 (mg/PMT)	40.16667			0	PM10 (mg)
Bus (off peak)	GHG (g CO2e/pmt)	490	0 (assume commutes happen during peak hours)			
	NOx (mg/pmt)	4000				
	SO2 (mg/PMT)	150				
	VOC (mg/PMT)	140				
	PM10 (mg/PMT)	160				
Bus (peak)	GHG (g CO2e/pmt)	61	0.012	13.86	10.14552	GHG (g CO2e)
	NOx (mg/pmt)	500			83.16	NOx (mg)
	SO2 (mg/PMT)	18			2.99376	SO2 (mg)
	VOC (mg/PMT)	17			2.82744	VOC (mg)
	PM10 (mg/PMT)	20			3.3264	PM10 (mg)
Rail	GHG (g CO2e/pmt)	80	0.018	13.86	19.9584	GHG (g CO2e)
	NOx (mg/pmt)	327.8			81.77954	NOx (mg)
	SO2 (mg/PMT)	368.2			91.85854	SO2 (mg)

	VOC (mg/PMT)	18.32			4.570474	VOC (mg)
	PM10 (mg/PMT)	11.46			2.859041	PM10 (mg)
Biking	GHG (g CO2e/pmt)	0			0	GHG (g CO2e)
	NOx (mg/pmt)	0			0	NOx (mg)
	SO2 (mg/PMT)	0	0.02	12.6	0	SO2 (mg)
	VOC (mg/PMT)	0			0	VOC (mg)
	PM10 (mg/PMT)	0			0	PM10 (mg)

1% reduction in driving:

	Impact Category	Amount	Proportion of people	Miles per commute	Total Impact	Total Impact Units
Car (average of all car types)	GHG (g CO2e/pmt)	280			-35.28	GHG (g CO2e)
	NOx (mg/pmt)	713.3333			-89.88	NOx (mg)
	SO2 (mg/PMT)	35.33333	-0.01	12.6	-4.452	SO2 (mg)
	VOC (mg/PMT)	826.6667			-104.16	VOC (mg)
	PM10 (mg/PMT)	80.33333			-10.122	PM10 (mg)
Carpooling (average of all car types)	GHG (g CO2e/pmt)	140			0	GHG (g CO2e)
	NOx (mg/pmt)	356.6667			0	NOx (mg)
	SO2 (mg/PMT)	17.66667	0	12.6	0	SO2 (mg)
	VOC (mg/PMT)	413.3333			0	VOC (mg)
	PM10 (mg/PMT)	40.16667			0	PM10 (mg)
Bus (off peak)	GHG (g CO2e/pmt)	490				
	NOx (mg/pmt)	4000				
	SO2 (mg/PMT)	150	0 (assume commutes happen during peak hours)			
	VOC (mg/PMT)	140				
	PM10 (mg/PMT)	160				
Bus (peak)	GHG (g CO2e/pmt)	61			2.029104	GHG (g CO2e)
	NOx (mg/pmt)	500			16.632	NOx (mg)
	SO2 (mg/PMT)	18	0.0024	13.86	0.598752	SO2 (mg)
	VOC (mg/PMT)	17			0.565488	VOC (mg)
	PM10 (mg/PMT)	20			0.66528	PM10 (mg)
Rail	GHG (g CO2e/pmt)	80			3.99168	GHG (g CO2e)
	NOx (mg/pmt)	327.8	0.0036	13.86	16.35591	NOx (mg)
	SO2 (mg/PMT)	368.2			18.37171	SO2 (mg)
	VOC (mg/PMT)	18.32			0.914095	VOC (mg)

	PM10 (mg/PMT)	11.46			0.571808	PM10 (mg)
Biking	GHG (g CO2e/pmt)	0			0	GHG (g CO2e)
	NOx (mg/pmt)	0			0	NOx (mg)
	SO2 (mg/PMT)	0	0.004	12.6	0	SO2 (mg)
	VOC (mg/PMT)	0			0	VOC (mg)
	PM10 (mg/PMT)	0			0	PM10 (mg)

Appendix III: Detailed Functional Decomposition

Concept	Description	Pros	Cons
Website application	Users would use a website to log in and keep track of their sustainable behaviors and choices	•Websites are easily accessible •Personally owning a computer may not be required as public computer are available	•Users tend to interact with applications on the go, and not always when in front of a computer •Cumbersome to separate log into a website thus not convenient for user •Verification of user behavior is difficult
Cellphone app	Users would be able to update their sustainability efforts on their smartphones	•A majority of cellphones in US are smartphones, so available to many users •Smartphones are mobile, thus able to use app anywhere •Verification of transportation can use intrinsic smartphone functions	•User must own smartphone to use •Verification may rely on users employing certain functions (ex. GPS)
Social Media	Create a social media (ex. Facebook, Twitter) centered around sustainability	•Functioning as a separate entity allows more functions, options and information to be incorporated into design	•Separate concept and not integrated into other applications, so users must be highly motivated to join
Meeting group (i.e. reading group	This idea is similar to weight watchers, for users to discuss ways to improve and encourage sustainability	•Users are very involved •Sustainable actions will be driven by other users, not service	•Sustainability fanatics are most likely core users •Little to involvement or incentive to join other than users

Incentive Structure Concepts			
Concept	**Description**	**Pros**	**Cons**

Gym-Pact Model	Users set weekly personal sustainability goals for themselves and are punished if they do not achieve these goals	•Users determine themselves what realistically can be achieved •Punishment as incentive functions well for many users	•Many users do not feel incentivized through punishment
Reward System	Users are positively rewarded every time they behave sustainably	•Positive rewards brings the focus to encouraging sustainability •Simple to understand and employ	•Reward systems (both positively and negatively) may not effectly work in long run
Educational Tool	Providing the most amount of accurate and useful information to users allows them to understand themselves what is sustainable	•Focus is on informing users about sustainability, which is more valuable in altering user behavior	•Users must motivate themselves to change their behavior

Incentives Concepts			
Concept	**Description**	**Pros**	**Cons**
Monetary	Money will be used as the incentive. For example, if Gym-Pact model is employed then users will pay money if they do not achieve their set goal	•Money is a strong incentive for many users •Source of revenue	•Focus is on receiving money and not altering behavior or increasing sustainability
Points per action	A single point is given to users for every action they take to improve sustainability	•Simple reward system •Easy for users to understand and employ	•Different sustainability actions have various environmental affects, and this method rewards users equally for all actions
Normalized actions	Points are allocated depending on the effect each action has. More sustainable behavior is	•Users are given specific targets or areas to focus on to allow those areas to be target	•Does not acknowledge unintended consequences of certain improved behavior (such as SO2 emissions addressed in

	rewarded more.		review)
Discounts	Users receive discounts for services within designated areas. For example, users who use public transportation will receive discounts on tickets	•Designers can specify what sustainable actions are encouraged •More frequent users will directly be rewarded more	•Relies on stores or companies be willing to give discounts to users

Verification Concepts			
Concept	**Description**	**Pros**	**Cons**
Accelerometer + GPS	Smartphones intrinsically have accelerometers and GPS. These would be used to track location and speed to verify transportation method.	•Uses intrinsic functions within deployment method •Tracks user location precisely •Can function independently of cell service	•Assumes smartphone as deployment method •User must employ GPS, which decreases battery life •Will only be applicable to behaviors that require location
Receipt, or Ticket Picture Upload	Users will take a picture of their transportation receipt or ticket and upload it to be verified. This will only be application to public transportation.	•Verification is strong as users cannot alter dates or modes of transportation •If users has smartphone app, easy to take picture and upload	•Requires a lot of effort by users •Requires a ticket per transportation, which many users do not have (i.e. monthly passes) •Not universally applicable to biking
Decive Attached to Bike	Having a separate device that communicates to a cellphone or a server will track where . Difficult to apply to public transportation.	•Simple for user •Device on bike transmits independently location of user	•Not necessarily universal, as this may be difficult on public transportation •Will only be applicable to behaviors that require location

Wi-Fi + cell towers	Location verification will be dependent on cellphone towers and Wi-Fi signals	•Intrinsic function in smartphone •Can be used in many areas without draining battery as much •Fairly accurate location	•Assumes smartphone as deployment method •Wi-Fi and cellphone signals are not always available •Will only be applicable to behaviors that require location

Concepts to Establish Revenue			
Concept	**Description**	**Pros**	**Cons**
Charge for design	Users must pay to use and interact with the service	•Revenue source will be consistent, predictable and	•Users will be discouraged from using service if they have to pay for it
Store	Items that encourage sustainability (example, reusable bags) can be sold online	•Items encourage sustainable behavior	•Limited amount of revenue source •Using more material may have negative consequences
Advertising	Companies that encourage sustainability will advertise and	•Advertisement can be used as advice to use certain products for increased sustainability •Using specific products gives users ideas of how to increase their sustainability	•Relies on companies be willing to advertise •Users may become irritated with continuous advertisement
Agreement with stores	This will give users access and discounts to certain stores with which the service has an agreement with	•Encourages users to buy products from specific stores that are sustainable	•Store must agree to give d •Strong verification of behavior will be required

Concepts for point structure			
Concept	**Description**	**Pros**	**Cons**

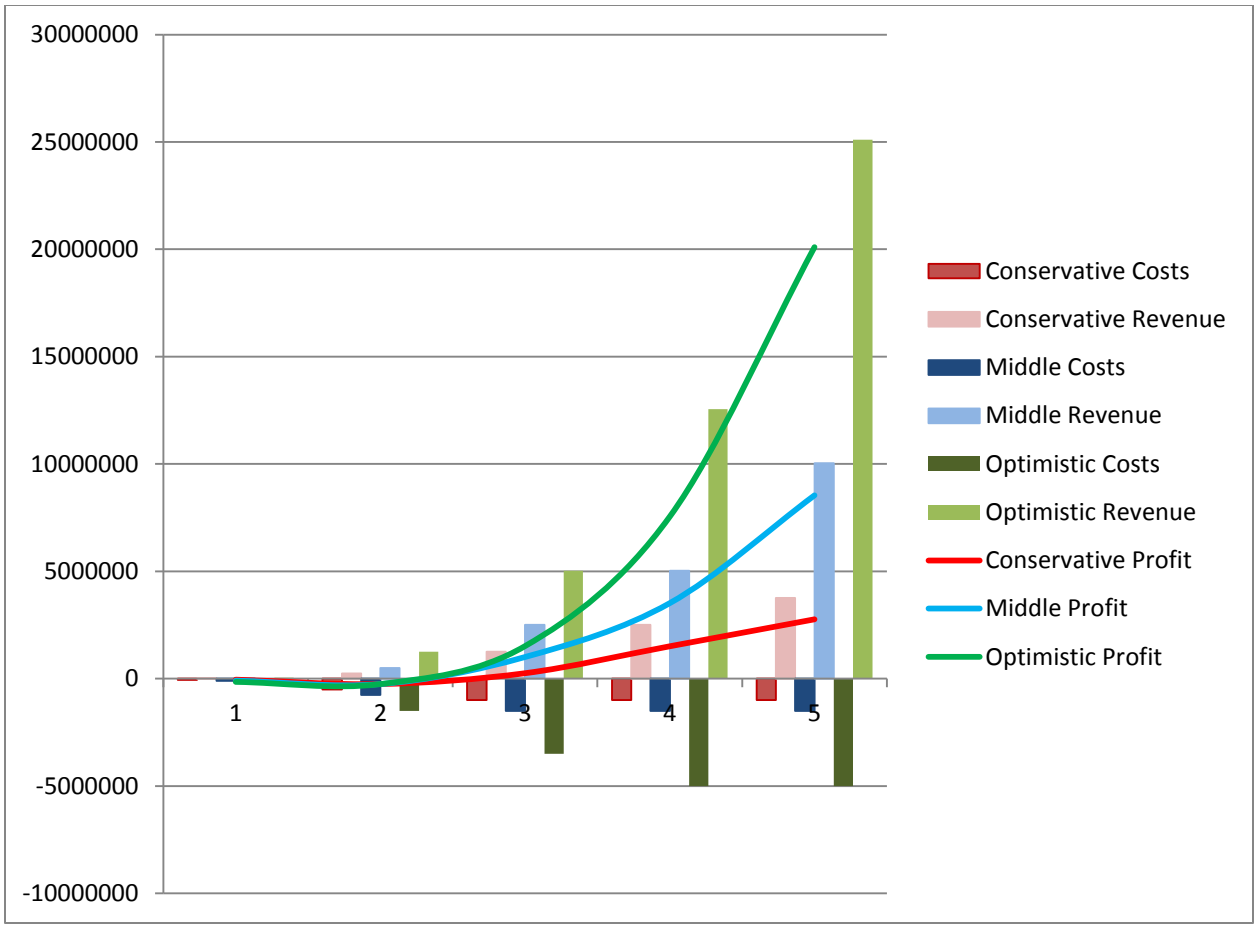
Amount of effort for each activity	Users are given points that are proportional to the effort of the activity. For instance, a user would receive more points for biking to work than for using a reusable bag	•Easy for user to understand •May encourage more sacrifice on behalf of the environment	•Not related to environmental impact •May encourage low-impact, high-effort behaviors which are counterproductive
Greenhouse gas potential	Users are given points equal to the greenhouse gases they mitigated	•Easy to understand for users familiar with global warming • Points are related to environmental impacts	•Prioritizes global environmental problems (global warming) over local ones (i.e. eutrophication potential) •May not be understandable for all users
Existing LCA indicator (e.g. EcoIndicator99)	Users are given points proportional to the existing indicator (EcoIndicator99)	•Incorporates all types of environmental impacts •No need to generate a lot of new information to add new behavior categories	•Incorporates a value system which may not align to users •How points are calculated may be unclear to users
Cost to mitigate that pollutant	Users are given points proportional to the cost to mitigate the pollutant	•Money is easy to conceptualize •Doesn't incorporate a value system (other than currency)	•Don't have a good understanding of how to mitigate some pollutants (carbon capture) •Just because a pollutant is expensive to mitigate doesn't mean it has higher ecological effects

Concepts for future applications			
Concept	**Description**	**Pros**	**Cons**

Transportation	Incorporate carpooling and driver behavior into the design	•high proportion of users are driving •May impact users who don't have access to public transportation or don't feel safe biking or walking •Technology exists within phone (accelerometers and bluetooth)	• Lower environmental impact than the transportation behaviors we already accounted for
Consumer Products	•Grocery plastic bags •Consumer products (shampoo, dish soap etc.) •Food choices: meatless, buying local	•Incorporate users' everyday behavior •Diet and others may have a large impact	•Need to understand all the possible options and the environmental impacts of these •May be hard to verify
Home energy use	•appliances •heating and cooling •lighting (e.g. LED)	•Users may be motivated by saving money	•Need to understand all the possible options and the environmental impacts of these •May be hard to verify

Appendix IV: Detailed Financial Projections

Round	Time	Conservative Costs	Users	Average log-ins per day	Average ads per log in	Conservative Revenue	Conservative Profit
1	6-9 months	-50000	500	2	5	5000	-45000
2	1 year	-500000	5000	2	5	250000	-250000
3	1 year	-1000000	25000	2	5	1255000	255000
4	1 year	-1000000	50000	2	5	2510000	1510000
5	1 year	-1000000	75000	2	5	3765000	2765000
Round	Time	Middle Costs	Users	Average log-ins per day	Average ads per log in	Middle Revenue	Middle Profit
1	6-9months	-100000	1000	2	5	10000	-90000
2	1 year	-750000	10000	2	5	500000	-250000
3	1 year	-1500000	50000	2	5	2510000	1010000
4	1 year	-1500000	100000	2	5	5020000	3520000
5	1 year	-1500000	200000	2	5	10040000	8540000
Round	Time	Optimistic Costs	Users	Average log-ins per day	Average ads per log in	Optimistic Revenue	Optimistic Profit
1	6-9months	-200000	5000	2	5	50000	-150000
2	1 year	-1500000	25000	2	5	1250000	-250000
3	1 year	-3500000	100000	2	5	5020000	1520000
4	1 year	-5000000	250000	2	5	12550000	7550000
5	1 year	-5000000	500000	2	5	25100000	20100000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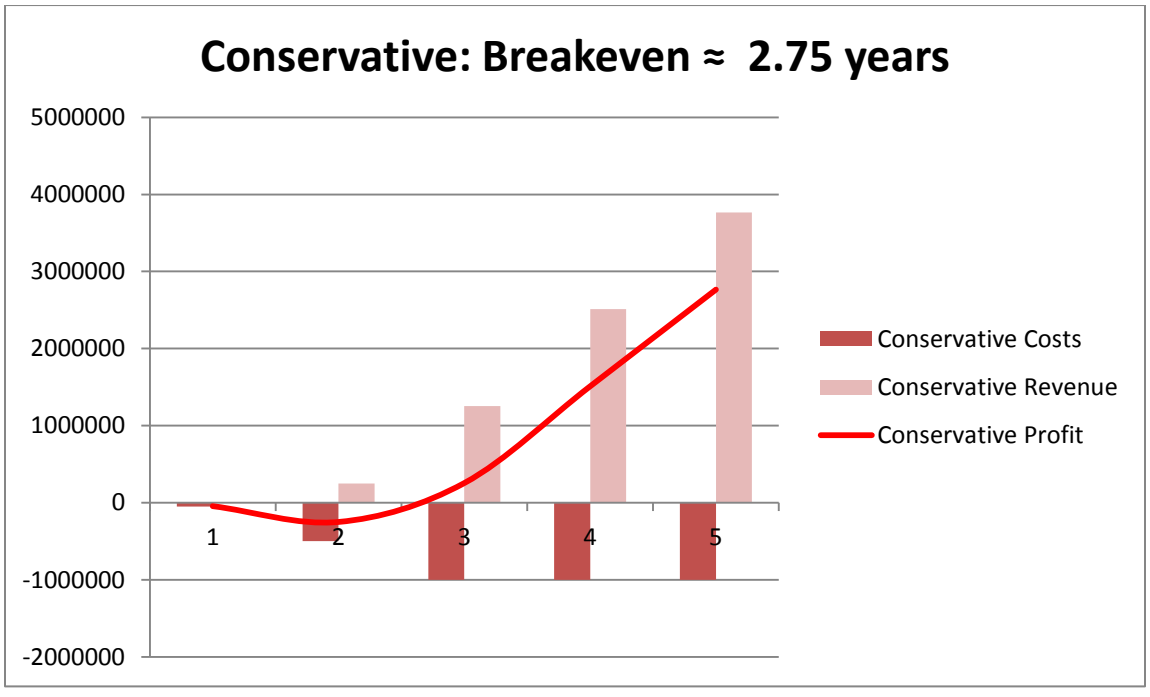
1
2
3
4
5
Conservative Costs
Conservative Revenue
Middle Costs
Middle Revenue
Optimistic Costs
Optimistic Revenue
Conservative Profit
Middle Profit
Optimistic Profit


Conservative: Breakeven ≈ 2.75 years
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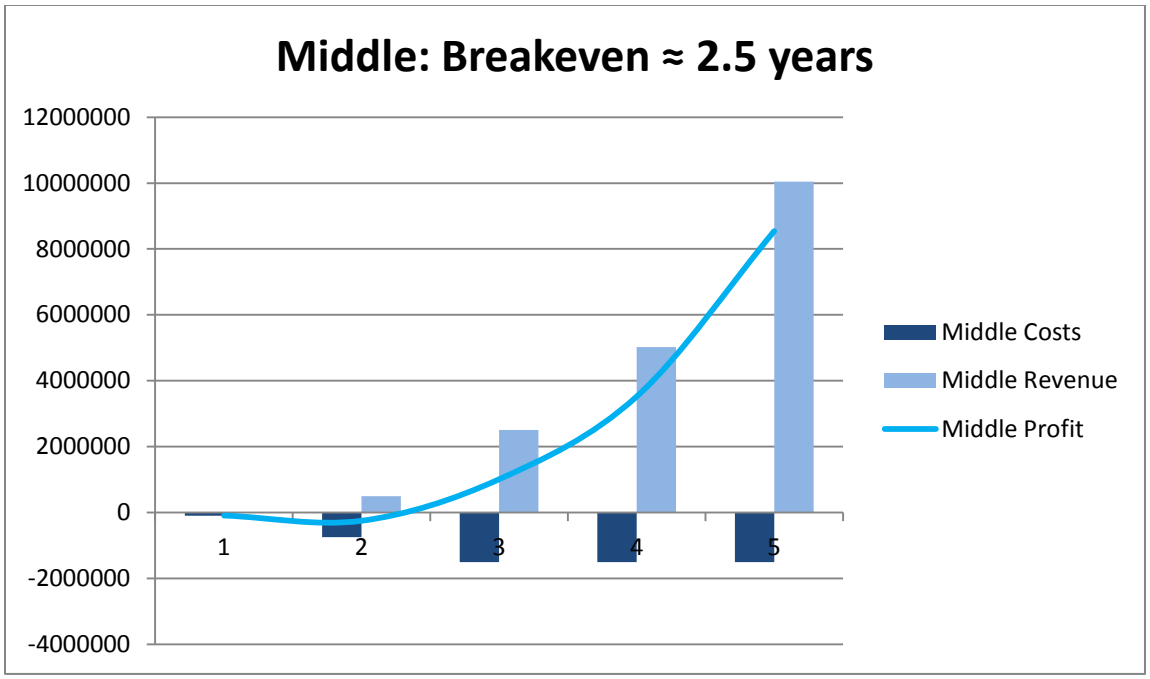
1
2
3
4
5
Conservative Costs
Conservative Revenue
Conservative Profit


Middle: Breakeven ≈ 2.5 years
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4000000
2000000
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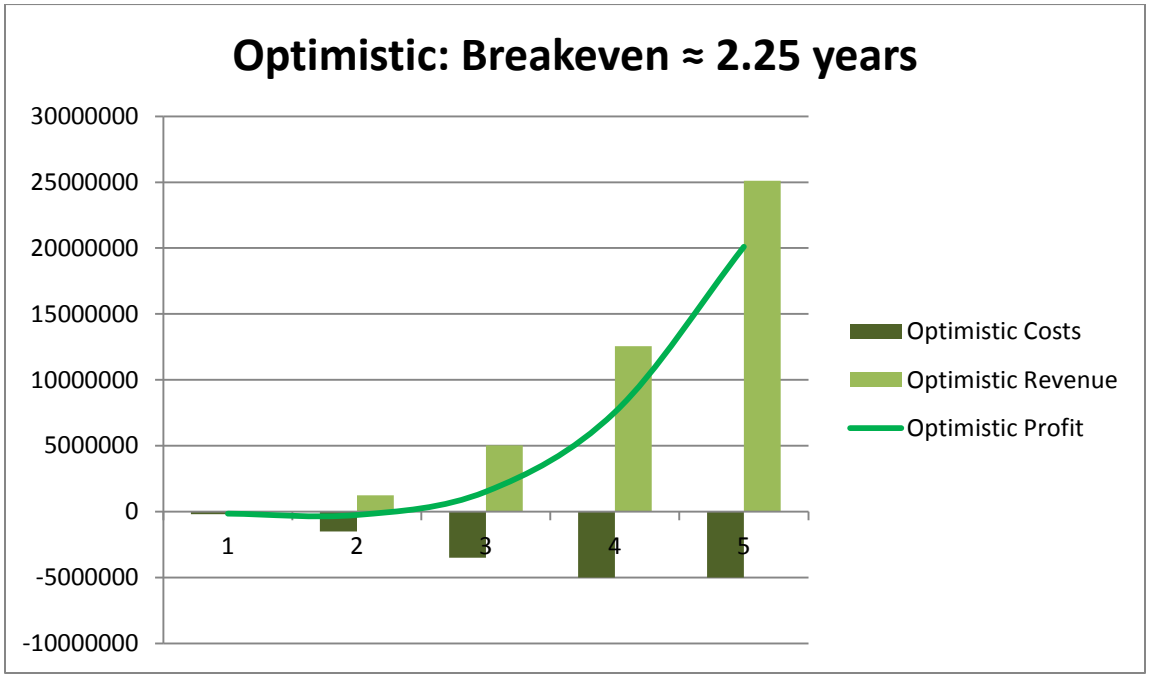
-4000000
1
2
3
4
5
Middle Costs
Middle Revenue
Middle Profit


Optimistic: Breakeven ≈ 2.25 years
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2
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4
5
Optimistic Costs
Optimistic Revenue
Optimistic Profit