powerplay

Prototype & Design

Summer Report

104 pages, 4 sections,

Team Silk, August 2011.

powerplay

Prototype & Design

a collaboration between
Carnegie Mellon University
and **Eaton Corporation**

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Executive Summary

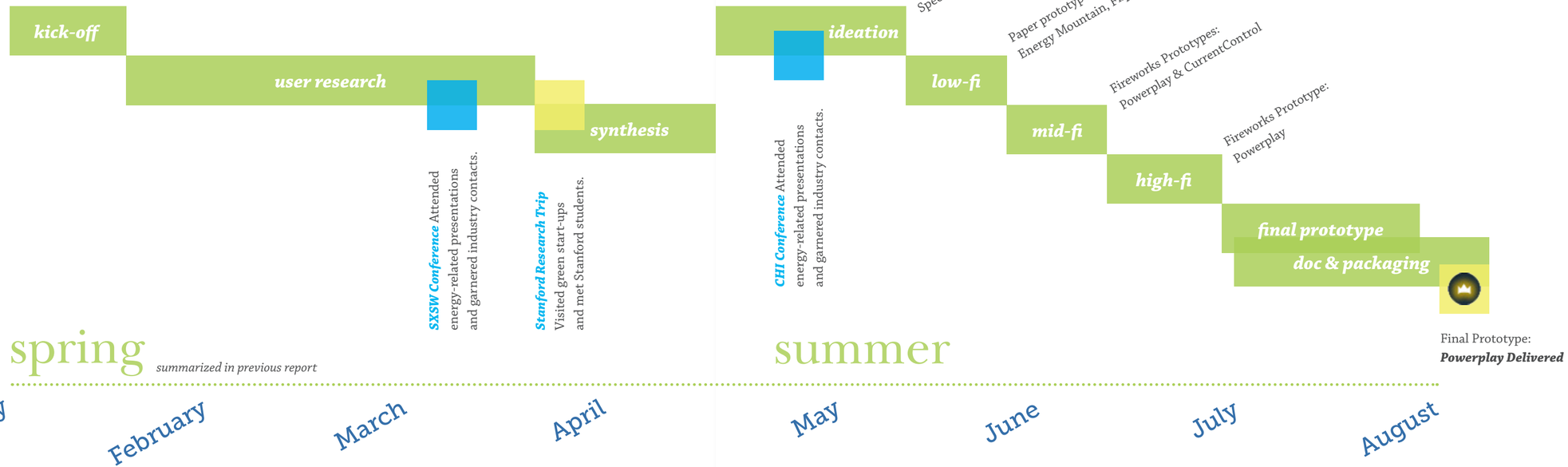
Members of Eaton Corp.'s electrical division approached Carnegie Mellon to explore the idea of using mobile devices to allow electrical users to better understand and save energy.

Team Silk explored various commercial and residential areas and concluded, with help from Eaton, that commercial users, while more likely to be Eaton customers, were much less likely to monitor energy use and change their behavior. The focus of the project then became residential users, with an eye toward potential commercial use cases and tie-ins with Eaton's forthcoming multi-point meter hardware. The final design, ***Powerplay***, includes real-time energy awareness and insights, social competition, straightforward and beautiful data visualizations, virtual savings rewards and energy saving tips. The product was designed and tested with residential users and the discussion of its place in that domain comprises the bulk of this report. The potential use of Powerplay in the commercial space is discussed in the Looking Ahead section.

The team used an innovative ***3-2-1 prototyping*** methodology to create Powerplay based on recent academic research by Steven Dow. Rather than produce a single concept, the team produced three concepts in the first round, two in the second and just one in the last. Eaton team members were involved at each step of the way and approved the final delivered concept. A diagram of this process is on the following page, and the development of the methodology is discussed at the end of the Prototyping Process section.

3-2-1 METHODOLOGY

Project Timeline



the Design

Powerplay...

is a mobile home energy monitoring application featuring a variety of tools to motivate energy use reduction.
These motivational tools include high resolution, real-time data visualizations, social competition, achievement awards, alerts and energy saving tips. Based on months of research, testing and iterative prototypes, this application is designed to promote both short-term improvements and long-term changes in energy consumption behavior.

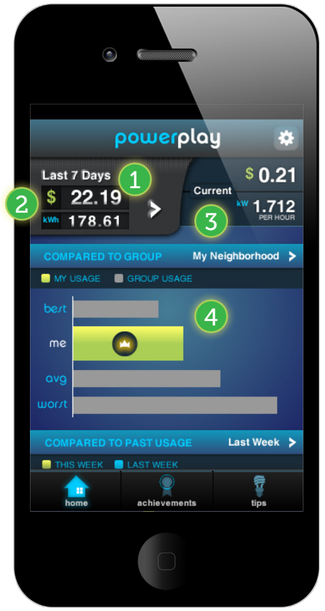
This chapter includes a detailed look at Powerplay's features, the persona that it was designed for and an overview of the application workflow through the eyes of that persona.

The screens of the application throughout the entire document are shown as they might appear in the Apple iOS operating system on the iPhone 4, released in 2010. The live prototype was also built for this platform. This was a choice made purely for ease in prototyping and shouldn't be considered a conscious design decision. More on platform selection is in the "Implementing Powerplay" section of the "Looking Ahead" part of this report.

Application Overview

1. Energy Header

The Energy Header is the most prominent feature of the application, displayed at the top of the home screen. Users can see their energy use in real-time in both kilowatts per hour and dollars per hour. This was included in the design to allow basic access to energy data, to allow users to understand the rate at which energy is being consumed and to provide cost motivated users with a real number on which to base energy use decisions. The Energy Header was also added based on numerous user accounts expressing the value of watching energy consumption on a physical meter. They noted that seeing numbers tick by, or dials spin was a strong metaphor in understanding their energy consumption.



2. Energy in '$' and 'kWh'

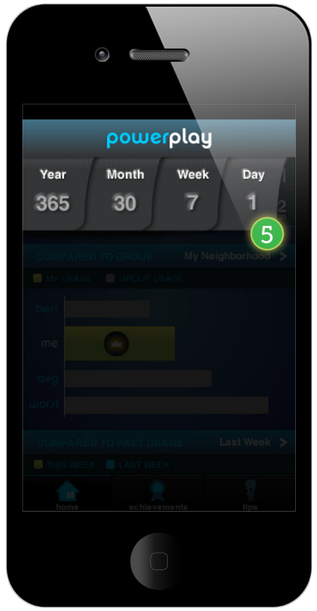
Energy information in Powerplay is presented in both dollars and kilowatt hours. This is something mirrored in many similar applications, sometimes with a system for toggling between either display mode. In this case, both figures were included to provide feedback in terms that users easily understand (money) and in a way that is easier to compare and which increments more quickly (kilowatts per hour). The dual metric also alludes to the dual nature of most energy savers. Some users are interested in big changes and saving money, while others more focused on in finer details and saving the environment.

3. Real-Time Usage

Under the Energy Header on the home screen, users have access to their real-time energy usage. This is a live number represented in both kilowatts per hour and dollars per hour, which indicates the current rate of consumption. Research and experience prototyping has indicated that providing real-time consumption figures enable users to better monitor their electricity usage. Users can instantly see if their consumption is high or low, and establish a mental baseline on which to compare themselves throughout the day. Just presenting the live information can provide insight into how much energy certain devices, like a space heater or air conditioning unit, use when in operation, and user can learn to adjust those devices more appropriately. This phenomenon was noted during testing when Team Silk installed energy displays in homes that provided real-time feedback on electrical usage and corresponds to results from numerous energy consumption feedback studies. Immediately users started gauging what devices used the most power and turn off heavy energy users, like a large screen TV, when it wasn't needed.

4. Social Competition /Comparison

One of the key motivators in energy conservation is social normative pressure. When users practice conservation they may say it's for any number of reasons, but studies show conservation behavior is most tightly correlated with users' views on how much their neighbors are saving. Powerplay taps into this phenomenon by showing users how they are performing compared to the average, best and worst energy consumers in any given group. These comparisons are driven by real-time energy data and are normalized using information about the housing unit (number of residents, year of construction, etc), which is collected in the settings screen. The bars change based on the time period a user selects and as they tap the various bars they can see either how they are doing or how far they are from others' normalized values. By default the user is compared to all users in their zip code, but the user can also switch to see comparisons with all Powerplay users or everyone on their submeter (if using an Eaton product).



5. Intuitive Time Windows

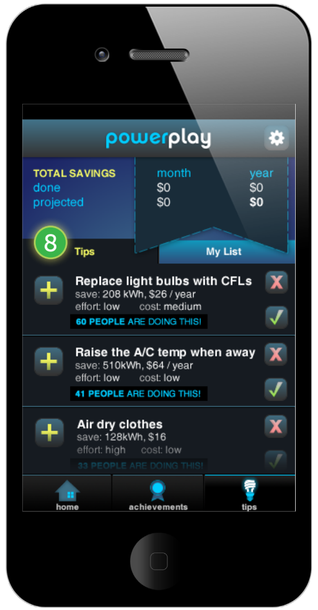
Energy data, like stocks or currency valuations, includes lots of data points, and the right level of resolution very much depends on the task. Powerplay includes four time windows, accessible via the Energy Header: This Year, This Month, This Week, and Today. "This Month" and "This Year" are meant to provide insight into long term trends similar to what people see on their current power bills. "This Week" and "Today" allows the user to think through more detailed, recent actions that may have impacted their usage.

6. Comparison Charts

Displaying energy use for the past year, along with how each month compares to the next, was a major innovation when it was introduced to paper energy bills, and it's a tool that users typically respond to and can understand. Users now receive an instant comparison against their own performance. The charts in Powerplay bring an additional level of interactivity that is impossible with paper by allowing users to see various time frames based on the Time Window menu selection context at the top compared against the previous period.

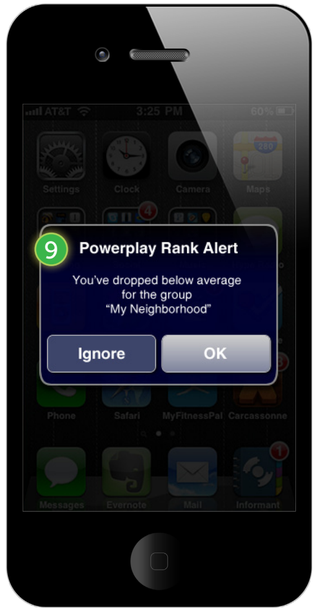
7. Data Insights

Time-based data visualizations allow users to make connections to data, analyze performance and create strategies for improvement, but it is not necessarily easy to derive insights from data, and not all users are interested in spending their time trying to analyze them. The insights section at the bottom of the home screen displays system generated insights that will provide instant feedback about data trends and anomalies. Users responded very favorably to this feature during testing. The Insights feature is one of three major features designed to provide higher level information outside of raw data.



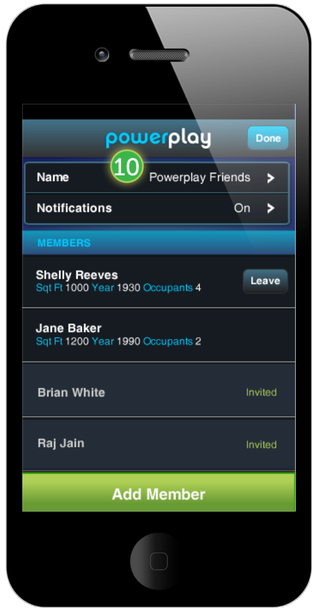
8. Energy Saving Tips

Energy saving tips are a component in many competing systems and applications reviewed, and based on the Team Silk primary research, it's not hard to see why. Users said that they don't understand where they are using energy or how to control it without compromising their quality of life. Tips are a great way for users to see actions that are available to them along with the potential impact and cost. In the Powerplay application, users can see a list of system generated tips and select those that make sense to them. They can then see the impact of those they've selected. Users can easily see how many users have committed to or completed each tip. It is critical that users are provided with realistic tips with accurate energy savings metrics and that the tips available are updated and improved during the lifetime of the application.



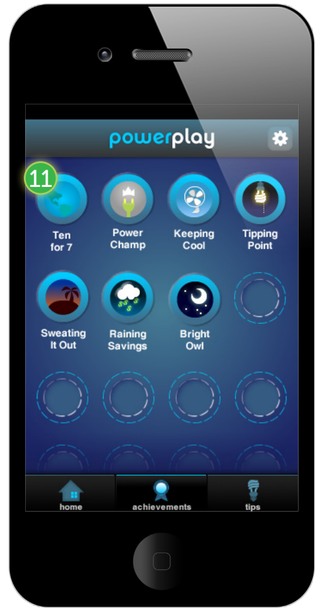
9. Alerts : Rankings /Usage

Alerts are part of the social competition ecosystem within Powerplay, and they are based on performance within the various groups to which the user belongs. Users get alerts when they reach the best spot, move above average or fall below, and at various other points in between depending on the size of the group in competition. The users current rank displays on the bar that represents their usage, and details about that rank are displayed when users tap on the bar. In addition, users may receive alerts regarding abnormal usage. For example, the notification may read: "Your usage is abnormal for this time of the day at this time of year."



10. Adhoc Groups

One of the key motivators of long term adoption of Powerplay is the integration of social networking. Powerplay includes a small social component that will allow users to create, in addition to the groups mentioned above, their own groups of friends, neighbors, coworkers etc. to compete against. No individual user data is displayed, because during testing, publicizing energy data proved uncomfortable for users. Just as with the other groups, the best, worst and average as well as the user's individual usage will be visible. These adhoc groups can be selected from the same screen that displays the application's default groups.



11. Achievements

In addition to social competition rewards, Powerplay includes earnable achievements. These are based on a large library of measures that both promote conservation and engagement with the application. A user might get a reward for creating or joining an ad hoc group, or for sustained improvement in energy conservation over the course of a month. All of the achievements can be shared online through various social networks. This is one of three pieces in the application driven in part by processes outside of the users own data. It is important that achievements are relevant to users and new achievements are added on an ongoing basis.

Key Research Findings

A summary of the five Big Ideas from User Research and Literature Review in the Research Report delivered May 2011. Team Silk interviewed a total of 30 users during this phase.

Energy usage is difficult to access and understand.

Very few energy consumers have access to real-time energy data, and those that do don't always understand what the numbers mean. The opportunity for a product to bridge this gap is keenly felt.

Energy usage is difficult to control.

Energy is necessary to maintain certain standards of living and business operations. Maintaining those standards make energy reduction difficult. Some variation in energy needs depend more on external factors such as the weather, daylight hours, business operations etc. that are beyond user control.

Comfort, convenience and function come before energy use reduction.

Energy bills are typically low and energy conservation maybe important, but is secondary. People don't want to compromise on comfort and convenience to save energy.

Comparisons can motivate energy use reductions.

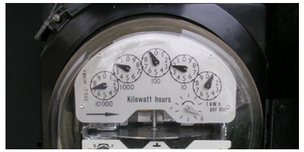
The most important tools researchers have found in motivating energy conservation are 1) the sense that people around them are conserving and 2) the ability to see how much energy is consumed by specific devices.

Sustainability motivates investment; cost motivates reduction.

This is a nuance noticed during user interviews. Concerns about reducing energy costs motivate people to conserve power by reducing usage, while concerns about sustainability and the environment tend to interest people in making investments like solar panels, upgrading to energy star appliances etc.

Key Testing Findings

The most important findings from user testing found during the design phase. Team Silk uncovered these insights during the prototyping process this summer (May-July 2011) through a total of 35 user interviews. See Prototyping Process section for details.



Watching real-time consumption is a powerful motivator.

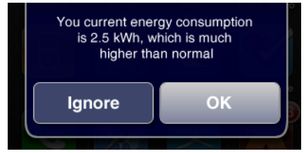
In several interviews we heard stories of users watching the dials spin on electrical meters and that being a powerful reminder of the impact of using certain appliances. The energy header in our prototypes was considered a powerful metaphor by users.

Too much comparison detail is discomforting.

Sharing individual user data when it comes to energy was something many users recoiled at during testing. They felt it was an invasion of privacy to look into someone else's power consumption, be it them or their neighbors.

Users don't want the solution and workflow to depend on others.

In a scenario during early prototype rounds Team Silk talked about discussing an application where in case the user was out of the house, he/she would involve their neighbor in the workflow. This was generally rejected. Users said they don't want an application that requires involvement of other people.



Alerts need to be actionable.

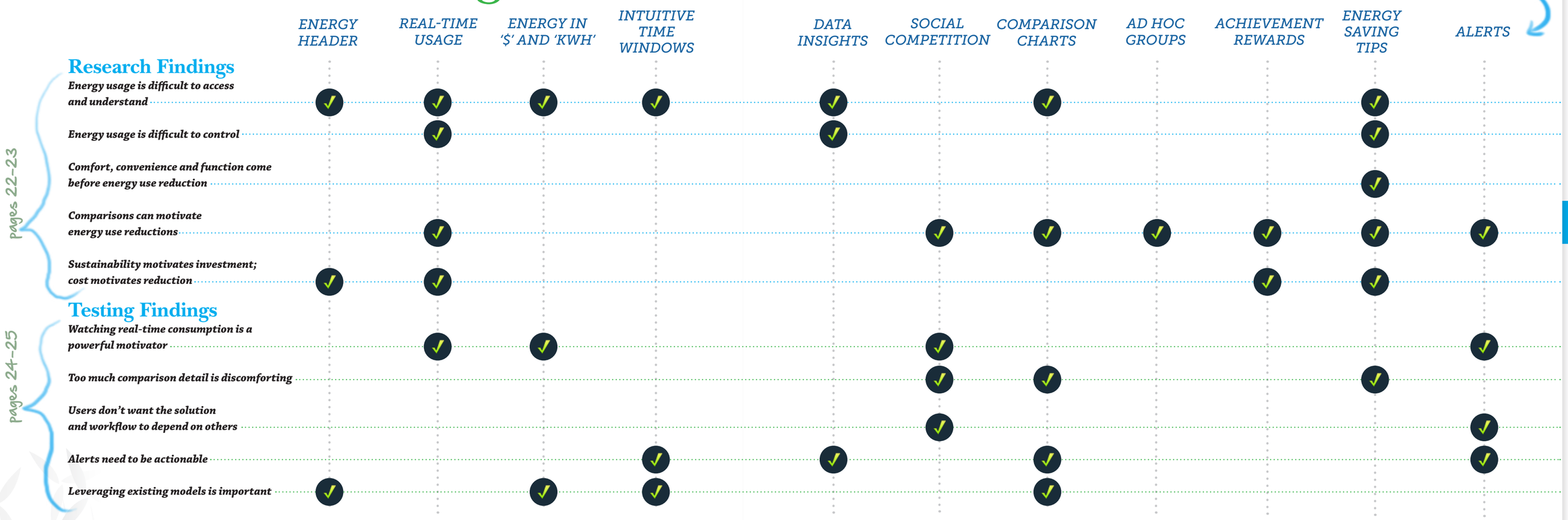
In initial prototypes, alerts occurred when a user was not at home, and this was unhelpful for many of the users tested. They said they wanted to know about their energy when they were in a place where they could do something about it.

Leveraging existing models Is important.

Users tend to be very aware of at least a few concepts related to their energy, including the amount of money paid each month and the printed comparison chart on the paper bill. Prototypes for Powerplay were built to leverage these concepts as much as possible.

Features vs Findings Matrix

Application Overview features presented on pages 14–21.



Application Walkthrough

USER PERSONA

Now that the core features have been presented, this section of the report will walkthrough the way the application might be used through the lens of a user. The user persona, Shelly, will be presented, followed by six separate workflows that will walkthrough Powerplay including setting up an account, checking daily usage, earning and sharing rewards, responding to alerts, committing to energy saving tips and creating adhoc saving groups.

Persona Selection

As part of the previous report, three user personas were compiled. They represented three groups, Danny, an engineer represented the knowledgeable and motivated energy conservers, Margaret represented the unknowledgeable, but motivated energy conservers, and Shelly represented the currently unknowledgeable and unmotivated users. Throughout the prototyping process, both Margaret and Shelly were used as guides, but Shelly has become the primary persona. Selecting a single persona as a focus rather than many, but expecting the design to serve many types of users, is a common practice in interaction design. Powerplay was designed specifically with Shelly in mind. But it benefits both Margaret and Shelly. It offers motivation to conserve power with the competitive portion to a large user base of people like Shelly (most energy users are not overly conscious or motivated about conservation) and serves Margaret with the detailed graphs, tips and projected savings.

Interest in Conservation

Interest in Energy Cost

Shelly Reeves

Shelly, 27, lives in an apartment with her husband and two children, ages five and two. She is a stay at home mom and takes care of the children and her home herself during the day. Shelly is very busy and doesn't have time for many activities outside of her home.

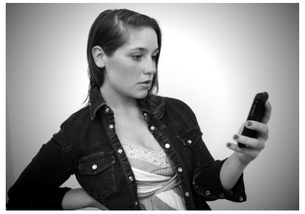
When it comes to electricity, Shelly feels her use is need-based and doesn't think about finding ways to save. Given the low cost of power, she just doesn't see the need to be frugal. She keeps a stack of her power bills and other bills and when the new one comes she compares it to the last. Usually, they are about the same.

She does want to be green and care for the environment where she can, like by using compact fluorescent lights. But she doesn't want to make big behavior changes. If there is something that saves money, is good for the environment and easy then she will do it happily.

SETTING UP AN ACCOUNT

1 OF 6

SHELLY DOWNLOADS POWERPLAY AFTER HEARING ABOUT IT FROM A FRIEND AND LOGS IN FOR THE FIRST TIME...



1. Shelly has opened up Powerplay for the first time and she's prompted to ***connect*** her meter.

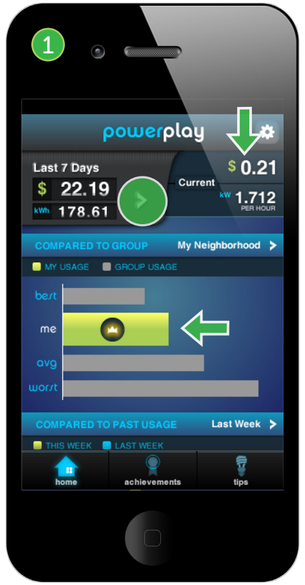
2. She enters her utility ***provider***, ***account number*** and ***password*** and taps ***connect***.

3. Once connected she's taken to the settings screen to fill in a few important stats about her home including the ***location***, ***number of occupants***, ***size in square feet*** and ***year of construction***, before selecting ***done*** to exit to the home screen.

4. If Shelly were to return to the home screen before completing all of the relevant information in settings she'd receive a notice on the home screen that more information is required before she can be compared to others.

REVIEWING INDIVIDUAL USAGE 2 OF 6

AFTER SETTING UP THE APPLICATION, SHELLY CHECKS POWERPLAY TO SEE HER ELECTRICITY USAGE...

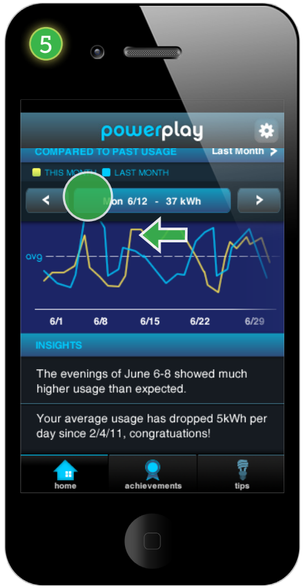


1. Shelly opens the app and sees the home screen including her current usage. She notes she is doing better than many of her neighbors in the last seven days. She wants to see how things have been going for the month, so she taps the ***time frame tab***.

2. The time frame tab appears and Shelly selects ***month***.

3. The month comparison appears, and Shelly can see she's doing worse than the average in her neighborhood. So she scrolls down to see a graph of the last 30 days.

4. She notes in the ***insights*** that a few evenings earlier in the month were high, so taps on the ***graph*** near these days.

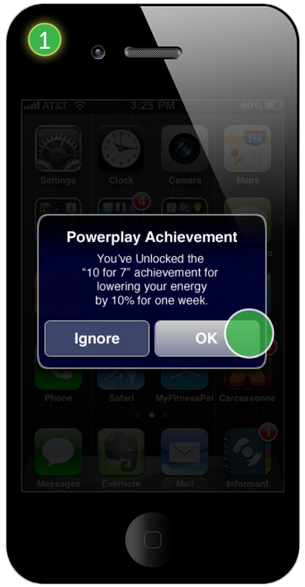


5. After tapping the graph, she sees the date and usage on a ***button*** above the graph, which she then taps.

6. Shelly can see a chart with a bar for each hour of the day she selected and the same day four weeks prior. She can see that her energy usage was much higher in the evenings than a month ago. She remembers her husband having fallen asleep in front of the TV and notes she should probably do better at turning off the TV at night for him. She taps ***done*** and returns to the home screen.

EARNING REWARDS 3 OF 6

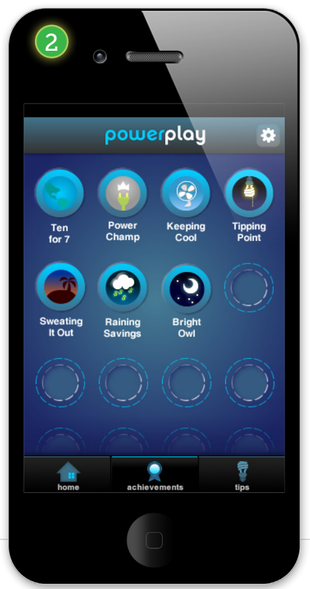
IT'S BEEN A FEW WEEKS SINCE SHELLY STARTED LOWERING HER ENERGY CONSUMPTION USING POWERPLAY...

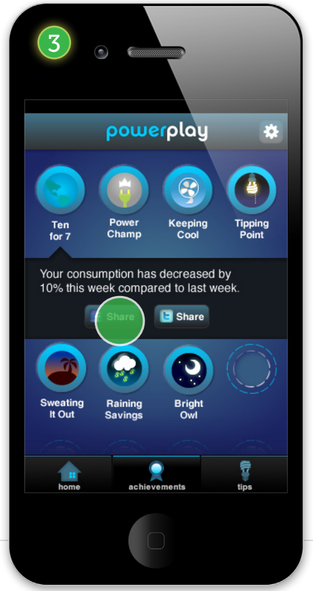


1. Shelly is busy working around the house when she gets an alert that she has earned a Powerplay achievement. She taps ***view*** to learn more about it.

2. Powerplay opens and takes her to the achievements screen, where she can see all of the achievements she's earned, including the new ***10 for 7*** achievement, which she taps.

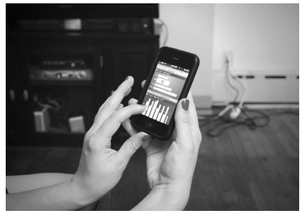
3. She reads the description and taps the ***Facebook share button*** to post the achievement to her wall.

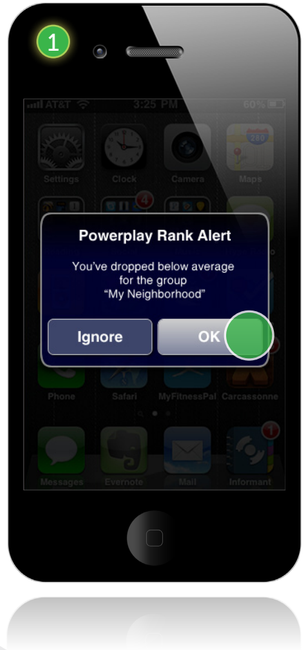




RESPONDING TO ALERTS 4 OF 6

AFTER A MONTH OF USER POWERPLAY, SHELLY HAS LOST INTEREST IN THE APPLICATION AND HAS STOPPED BEING AS CONSCIENTIOUS ABOUT HER ENERGY HABITS...





1. Shelly receives an alert that she has dropped below average for her neighborhood. She taps ***view*** to see more details.

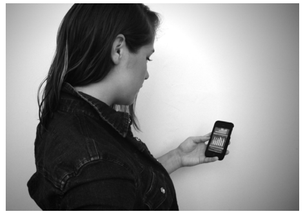
2. The app opens to the home screen. She taps her ***bar on the group comparison graph*** and sees she's in the bottom 40 percentile for her neighborhood this month, right back where she was before she started making improvements.

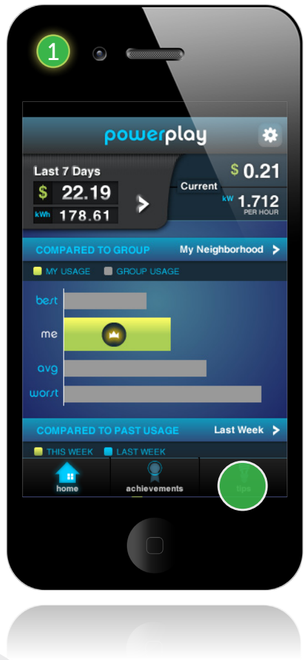
3. She then taps on the ***average bar*** and sees that she is only 5 kilowatt hours per month from the average. Determined, she resolves to do better.

4. However, later that week, Shelly gets another alert that her energy is quite high based on the temperature and time of day. She looks around the house and finds two fans and several lights that were left on and turns them off.

COMMITTING TO CONSERVE 5 OF 6

AFTER A WEEK OF POOR RANKINGS AND ALERTS, SHELLY HAS HER ENERGY USAGE ON HER MIND. SHE REMEMBERS SEEING SOMETHING INSIDE POWERPLAY THAT MIGHT BE ABLE TO HELP HER IMPROVE...





1. After opening Powerplay, Shelly taps ***tips*** on the bottom navigation bar.

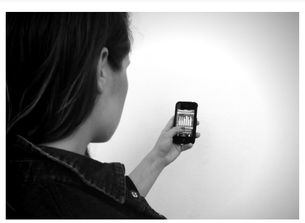
2. She scrolls through the list of tips, which she notices is ordered by popularity. She taps the ***+ button*** on the top two tips that she feels she can do relatively easily. She taps the ***x button*** on another to hide it because she doesn't feel it's realistic, then scrolls down to review a few more.

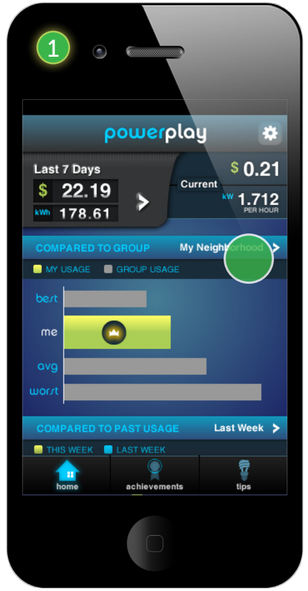
3. After scrolling, she sees a tip she has already completed and taps the ***√ button*** to mark it as "done." She then selects ***My List*** to review what she has selected.

4. She can see all the tips she added from tips in My Lists. She can also see ***projected savings*** from these tips as well as the savings she already made from the tip she marked as done.

CREATING A GROUP 6 OF 6

AS SHELLY STARTS TO SEE BENEFITS FROM POWERPLAY, SHE SHARES THE NEWS WITH FRIENDS AND DECIDES TO INVITE THEM TO A GROUP...





1. After opening Powerplay, Shelly taps the ***compared to group*** bar.

2. She's taken to a list of groups that she's already a part of. She taps ***add a group*** to create the new group with her friends.

3. She enters the group name then taps the ***add member*** button to select people from her address book. Once they have been selected, an email is sent to them via the phone's native email client, and they appear as ***invited***. After they accept, details about their residence will show. She and any other member can leave the group at any time by tapping ***leave***.

4. Shelly can select the group from the list and view it on the home screen as soon as it has been created, but until she has at least three members in the group, she'll get a warning about not having enough group members.

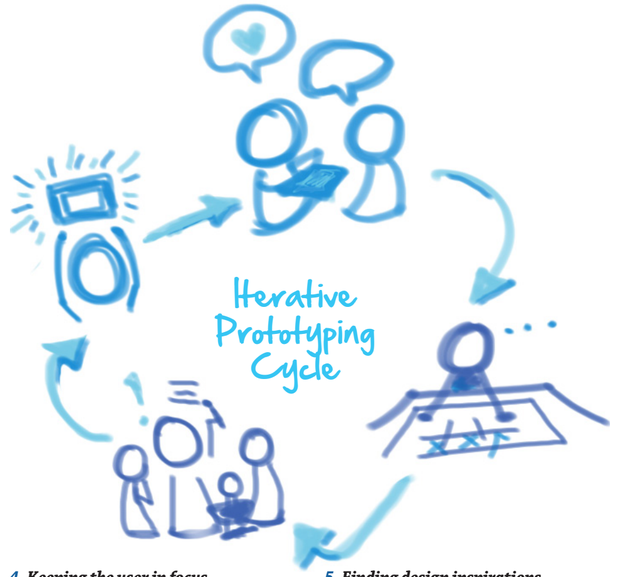
Prototyping process

In many ways, good design...

is inseparable from good process, especially when it comes to a project of some complexity. It is the process that allows the best ideas to rise and stay at the top, and creates the refinement that can lead to reliable and positive results. In this chapter, the process that lead to the creation of Powerplay will be reviewed, including results of each round of prototype generation and testing. This chapter will also include both implicit and explicit references to the guiding concepts that underpinned the design process including:

1. *Iteration*
The standard iterative prototyping model used by industry designers includes ideation, prototype creation, user testing and analysis, which circles back to more ideas and subsequently, a new prototype. This process was a part of everything produced by Team Silk and details about this method are woven throughout this chapter organized by prototype rounds or versions.

2. *Low to high fidelity*
Rather than immediately jumping into code creation or pixel-perfect application visualizations, each design concept was tested at a low level, using hand drawn sketches, then rough digital tools before moving into advanced visual programs and code implementation. This evolution is highly visible in our process explanation.



3. *3-2-1 Prototyping*
Based on recent research in the field of Human-Computer Interaction, Team Silk adopted what has been called the 3-2-1 Methodology, which involved creating at least three distinct and complete application visions during early prototype phases, narrowing the focus to two for the next round, then settling on one core vision for the final product. More advantages of this method appear in the 3-2-1 Methodology section of this chapter.

4. *Keeping the user in focus*
In the midst of the design process it's easy to blur the lines between different types of users and mash together lots of user needs. Team Silk combated this tendency by both building on the research of the previously delivered research report, including the five big ideas related to users and energy, and tailoring design visions to specific user personas based on user research. In the end the core focus was on one persona. More on the primary persona is included in the workflow examples section.

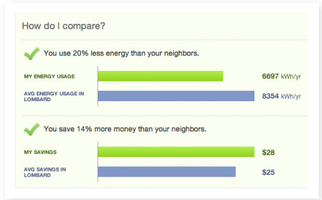
5. *Finding design inspirations*
A leader in the field of design, Bill Buxton speaks often about the need for designers to understand their history, because invariably something from the past or present can instruct future design. Team Silk took this to heart and looked to other products and tools for inspiration throughout the design process. More on this process is detailed in the design inspirations section.

Design Inspiration

During the user research phase of this project (Jan-May 2011), Team Silk performed a competitive analysis of various products and services in the energy management space to get a sense of existing designs trends and opportunities. As the design concepts narrowed over the course of the prototyping phase, the team explored additional concepts and looked again at previously evaluated products for ideas and inspiration.

Comparison Engines

One of the major insights from the research phase was that "comparisons are crucial" in motivating energy use reduction, and one of the key ways of comparison is with other energy users. This is due to social normative pressure, which studies have shown to be one of the most important factors in motivating behavior change. Hence, social comparison became a key principle in Team Silk's final design.

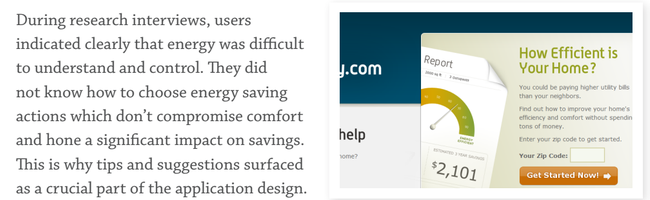


Efficiency 2.0 and OPower

These services are contracted through utility providers and connect users with their energy data via printed and online reports. They compile massive amounts of data and compare electricity users with their neighbors and those most similar to them. This data is used to show how well an individual is performing and to provide guidance for improving.

Energy Tips and Suggestions

During research interviews, users indicated clearly that energy was difficult to understand and control. They did not know how to choose energy saving actions which don't compromise comfort and hone a significant impact on savings. This is why tips and suggestions surfaced as a crucial part of the application design.



EnergySavers.gov

EnergySavers.gov is run by the US Department of Energy and is loaded with information about energy audits, the types of repairs that can have an impact on energy bills and even tips on driving and car maintenance. The site is difficult to navigate, but the information is invaluable.

EnergySavvy.com

This site is at its core an engine to help provide a user ranking based on home energy efficiency including insulation, energy efficient appliances, etc. It also generates recommendations and projected savings for home improvements. All of this is based on a simple, graphic-driven questionnaire. It's also designed to connect site users with home repair and efficiency experts that can help homeowners access these services and make any needed repairs.

EarthAid.net

Earth Aid has been billed as the online Mint.com (a financial tracking tool) for home energy. It's a platform for aggregating and viewing all utility bills leveraging connections with utility providers databases. The site includes a dashboard and graphs (as might be expected), but it also includes a social network component, which has been tied to the "ways to save" feature. Users can see not only what tips might be applicable to them, but how many other Earth Aid users have said they will do or have done a certain tip.

Always Present Data

Team Silk discovered during research that a very simple, but fundamental problem energy users face is not having feedback about their energy consumption. People just don't understand how much their devices are consuming. This is a problem multiple services are trying to address.

The Energy Detective and Energy Hub.

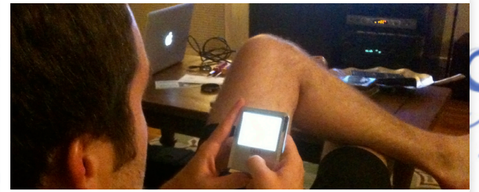
The Energy Detective (TED) and Energy Hub are tools for providing real-time energy data in a form factor that is constantly presented to the user. TED includes a web interface and Energy Hub has both a mobile application and web site, but most importantly, both of these systems include an in-home hardware device that constantly displays real-time usage. This type of display prompts users to look around at what may be turned off and take action in the moment. This is not something that could be accomplished via a mobile application, but the final design tried to incorporate the idea of real-time communication as much as possible.

EXPERIENCE PROTOTYPING

In March, Team Silk installed the first TED device in the home of a team member and immediately noticed responses from roommates who looked around for devices to turn off and use less. In June, two additional devices were purchased and installed. These external displays stimulated conversation at all three homes and prompted reviews to determine energy efficiency.

"You know what takes a lot of energy? 'World of Warcraft,'" one participant said. She was in the kitchen and noticed a spike. She investigated and found her husband at the computer. "I had no idea how much energy my microwave used, not to mention the washing machine," said another participant.

It was clear from the intensity and consistency of the reactions that the display was having a real impact on energy consciousness and promoted energy saving behavior.



3-2-1 Methodology

Design is a discipline where practices shift and mold themselves to each project. In part this is because what designers make comes from a creative space that thrives on fresh ideas and innovation. Additionally, not all of the best practices have been fully developed or well communicated.

One undisputed best practice is iteration: "Keep working until things are right, and not a moment beyond." A colleague at a large and successful medical software company asked a member of Team Silk about the education he'd received at Carnegie Mellon. His firm doesn't practice anything like iterative or interaction design, and he asked pointedly "So what's the magic, what's the secret sauce?" The answer supplied was no secret at all, "Iteration."

Yet, the methods of iteration, and the most effective ways to what aren't always apparent. When have enough ideas been generated to start prototyping? What counts as a prototype iteration? When should fidelity be increased or decreased? The fact is that these questions aren't definitely answerable and still must be answered for each and every project. Little practical experience, as precious as it might be, and from rubrics to draw on, don't help the designer's cause either.

Creating the 3-2-1 Methodology

Taking a cue from a recently published paper by HCI researcher Steven Dow [1], Team Silk created a new iteration methodology as a rubric to guide their design process for this project. Dow presented in his paper that groups that worked on multiple simultaneous designs vastly outperformed groups that created a single design in terms of "outcome, exploration, sharing and group rapport." The team used this method to construct a pyramid approach leveraging multiple designs early on while ultimately driving toward a single final product. The process which the team dubbed "3-2-1 Methodology," it involves creation of three low fidelity prototype concepts, two medium fidelity concepts and a single high fidelity design.

Mechanics

A standard design evaluation process resembles a very wide funnel, which shrinks to a very narrow spout. At the top are dozens of complete or component ideas that arise from user research. These ideas are then quickly narrowed into one or two concepts on route to a final concept which is tested and iterated upon.

The 3-2-1 Methodology borrows this existing top-down process of idea creation, but instead of the narrow spout with a single iterated idea, the funnel narrows more gradually, with three complete low fidelity prototype concepts, two medium fidelity prototypes and a single high fidelity prototype. Each step down the funnel may involve abandoning concepts entirely from a previous round, or reformulating the best components from the previous rounds in to fewer prototypes. Engaging in the latter may require some lower fidelity sketching as part of the reformulation, but, as was the case with this project, the new designs should be able to borrow enough insights from earlier prototyping rounds to avoid starting back at the low-fidelity entry point.

The specific numbers involved in methodology (except perhaps the last "1") are not critical to the process—it may make sense to go from 4-2-1 or 5-3-1— 3-2-1 is just the simplest. The idea is that multiple, complete prototypes are being created simultaneously.

Benefits

The benefits of this methodology are numerous. As Dow suggested, these benefits fall into two buckets, "design outcomes and interpersonal dynamics." Design outcomes in Dow's research study were measurable by click-through rates of ads created by student teams. In the case of this project, this evaluation is much more subjective, but based on feedback from advisers, Eaton team, and satisfaction within Team Silk, the outcome quality is assumed to be high. Interpersonal dynamics are also difficult to measure, although perhaps more discrete because it only involves the team members. Members of Team Silk have remarked regularly at how well they feel the team gets along and how they feel this particular design methodology has helped foster team unity. Below are a few specific benefits that seem to have improved both design outcomes and team dynamics.

Safe Environment for Failure
A key tenet of design is the idea of "failing early"—it's the entire point of prototyping in the first place—figuring out a design space before committing to expensive research and development. Yet, in practice, prototyping doesn't always feel safe. As Dow puts it, "people presenting designs often believe their status to be on the line. This risk encourages over-investing time, labor, psychological energy, and social momentum into a single concept." Multiple designs effectively short circuit this kind of thinking because with multiple ideas at play, it's harder for a single idea to be too heavily weighted, and it becomes easier for team members to, as Dow also notes, "more effectively understand underlying design principles, enumerate more diverse solutions, and react negatively to feedback."

All the Best Ideas Advance
Starting an iterative design and testing process is a little like a reality show. The team comes back each week with fresh ideas, hoping to make it through to the next round. The problem with selecting only one main concept out of the gate is that the team has effectively chosen a winner already, albeit one that may be modified or scrapped. Conversely, the 3-2-1 Methodology promotes a marketplace of ideas. All of the best ideas advance from round to round either as complete prototypes or components. Poor concepts will naturally fall by the wayside, and highly competitive concepts will force important discussions about targeting the right user group and what end deliverable needs to be. Further, having prototypes to talk about, rather than just ideas, can enable a much better level of discussion for such conversations. Team Silk members noted that other project teams would spend hours hashing out the directions they were deciding on while their team simply built, tested, evaluated and decided.

Cross Pollination
A benefit that has been mentioned above is the cross pollination of ideas across prototypes. In the case of the three early prototypes for this project, there were clearly favored ideas (prominent real-time usage) and clearly disliked ideas (abstracted energy use widgets). Rather than evaluate these in the context of their prototypes, all of the ideas were reviewed individually. Even though the overall "Energy Mountain" application idea didn't survive, components of it did, and components from other concepts influenced each other for the best.

All Hands on Deck
On a team of any size, the project requirements don't always allow for a uniform division of labor. There may be a lot of visual design work falling to one adept in Adobe Creative Suite or programming falling to a proficient coder. With three simultaneous prototypes in the works, such luxuries can't be afforded. This may mean some of the early prototypes may be rougher than the others, but it also allows everyone to get involved, avoiding the possibility of any one team member hijacking the early design phase that influences subsequent iterations. This also allows every member to contribute. For early prototypes Team Silk used Mockups by Balsamiq, a visually rough, digital tool that helped level the playing field in terms of what these early prototypes looked like.

Challenges

While, for this project, downsides to this methodology seem negligible, if present at all, it's clear there are reasons why it could cause problems.

Time Consuming
Based on the user research completed for this project, the design concepts for what would eventually become Powerplay, were not particularly complex. User engagement time is measured in seconds and minutes and the screen counts were relatively small. This, no doubt, made it easier to create multiple, complete concepts quickly. Extreme complexity on a project might make creating three separate early stage prototypes, or two medium fidelity prototypes prohibitively difficult. However, in many cases this may not because for two reasons.

1. The time required to create prototypes in parallel is much smaller than the time required to create them in series. This is because multiple prototype concepts can often be hashed out in a single group session (with less arguing because consensus isn't required). It also leverages team resources more effectively.

2. Complete concepts may not be required to achieve the aims of this methodology. Perhaps a feature-wide concept or one or two deep features will suffice.

Analysis Paralysis

Another potential downside of multiple prototypes is something noted by Dow. "Increasing options can cause analysis paralysis--a "paradox" of choice--and may jeopardize a group's ability to achieve consensus." This can be a challenge when groups try to narrow down ideas internally and when designers must work with external stakeholders. Team Silk ran into this problem in the transition from two medium fidelity prototypes to a single high fidelity prototype. It took a few visits with Eaton and discussions with multiple stakeholders to get to the final decision to move forward with Powerplay. This put the project behind by a week, which, given the way the project schedule was arranged, wasn't catastrophic, but certainly could have been if the delay was significantly longer.

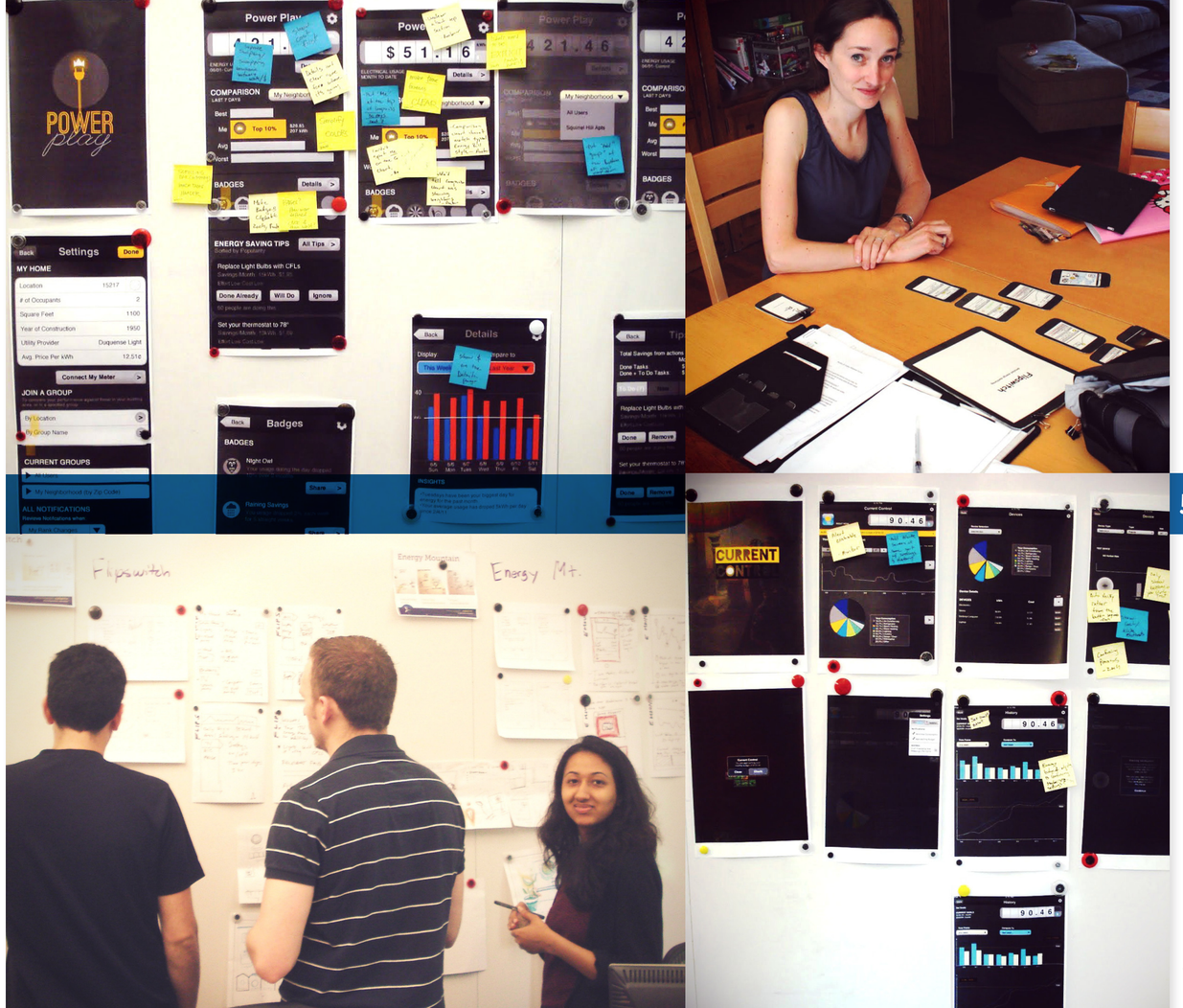
Less Refinement of a Specific Concepts

One danger of this process is that the final, high fidelity prototype can become less of an iterated, refined model than a patchwork of pieces of successful concepts. To avoid this, it's important to thoroughly test individual components that are added to or modified on existing designs, and to retest the composite interface that they have been integrated into. Over optimization can often be as bad or worse than under optimization and with this model it may be quite tempting to assume a whole workflow is well received just because the component parts have been tested and passed scrutiny. In some ways, refinement may be fundamentally opposed in some ways to expansive iteration, but Team Silk didn't find that to be the case through the course of this project. Rather it helped to dial in the right degree of refinement at the right stage, almost forcing low-fidelity and avoiding overthinking in the early rounds, allowing for multiple ways to express certain types of refinement, so the best can win out.

Conclusion

The 3-2-1 methodology provides a rubric-like framework for pushing a wide path of innovation on a project. It can be very easy for a team spending weeks or months digging into user research to then stop at the first best idea they find to develop. This model pushes against that concept, forcing a team to develop multiple visions before settling on a final idea. While the process may have its drawbacks, and may be unrealistic in certain settings, it seems to have general applicability, and the power to produce both powerful design outcomes and a positive team dynamic, all without taking significantly more time than a traditional approach.

1. Dow, S.P., Fortuna J., Schwartz D., Altringer B., Schwartz D.L., Klemmer S.R., *Prototyping Dynamics: Sharing Multiple Designs Improves Exploration, Group Rapport, and Results*, Computer-Human Interaction(CHI) Conference 2011, 1-9.



Prototype Creation

This section explains the prototype creation process from ideation through the creation of the prototypes that precede the final functional version. Each phase of the process, except ideation, included a complete design testing cycle and evaluation. Prototypes were tested with a total of 35 users during this phase.

IDEATION

Idea generation methods for the project included brainstorming and bodystorming with Eaton stakeholders, internal brainstorming and concept speed dating.

Concepts x11

PAPER PROTOTYPE

The team turned the most promising concepts from the ideation phase into three paper prototypes generated using a specialized software tool that focused effort on interaction over visuals. These prototypes were then tested with potential users.

Prototypes x3

INTERACTIVE 1

The feedback from the paper prototypes was evaluated and recombined into two new prototype concepts. The resulting prototype concepts, Powerplay and CurrentControl, were created using a more refined digital tool and clickable versions were loaded onto a phone and tablet for testing.

Prototypes x2

INTERACTIVE 2

Discussions between Eaton and Team Silk concluded that Powerplay was the favored design for final development. Another interactive prototype was created with improvements based on testing feedback and a more refined look and feel.

Prototype x1

FINAL PROTOTYPE

As this second interactive prototype was created, work also began on a code-based version of the application using HTML, CSS and JavaScript frameworks. True final interactive prototype and coded version were synchronized and tested throughout the final stretch of the project. The results from this phase are in the design section of this report.

Brainstorming from Big Ideas

Brainstorming from insights based on user research both with Eaton stakeholders and internally within Team Silk allowed the best ideas to surface.

Process

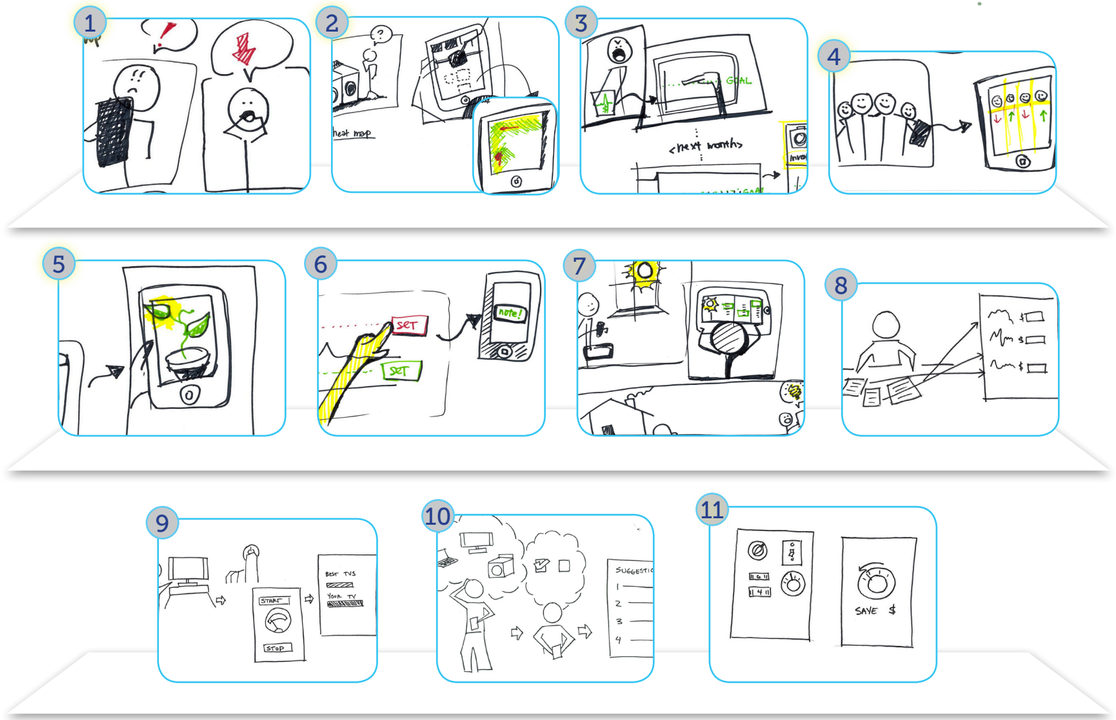
The brainstorming process took place in three phases pictured below.

1. After presenting ideas to Eaton stakeholders in May, the Eaton group together with Team Silk wrote down ideas, grouped them on a white board and acted out example scenarios, a process known as body storming.
2. Team Silk held additional brainstorming sessions, refocusing on ideas derived from user research.
3. The ideas were grouped using an affinity diagram to bring out key trends and concepts.

Outcome

Eleven key concepts were identified as possible design directions.

1. Multi-unit comparison tool (showing ranking, notifying users of changes).
2. Heat map showing household areas using large amounts of energy.
3. A tool for setting an energy savings budget.
4. Create teams with friends and family to save together.
5. A widget to show abstracted energy use with colors, traffic, etc.
6. Energy peak and valley notifications system.
7. Time sensitive alerts that look for abnormal energy use.
8. Total utility budgeting tool that allows users to see trade-offs between electric, gas and water.
9. Utility for testing how much individual devices use by monitoring changes in real-time usage.
10. A tool to help make energy efficient appliance shopping decisions.
11. A tool allowing users to test energy consumption with various virtual appliance settings.



Speed Dating 11 Concepts

Speed dating rapidly explored the eleven design concepts identified during brainstorming to discover, compare, and analyze user reactions and contextual understanding without requiring technology or wireframes.

15 PARTICIPANTS
6 women (25-40 years old)
9 men (26-51 years old)

25 29 35
25 35 40
26 27 42
26 27 42
27 32 51

Process

The eleven concepts mentioned in the previous section were sketched as letter sized posters (images on the previous page). These sketches were then shown and described to testing participants to gauge interest and gather feedback.

Testing was done with users in Pittsburgh and New York, as well as over the phone in Seattle and California. Users responded well to the process as well as the ideas. The team was able to weed out some ideas and promote others for further consideration.

Outcome

Based on the speed dating interviews, four of the concepts proposed during ideation were dropped, seven survived as pieces of a product and were arranged in three groups. Letter-sized posters of these groups (shown on the next page) were delivered to Eaton for review.

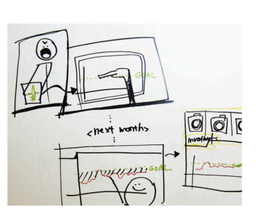
Energy Mountain
- A widget to show abstracted energy consumption using colors, traffic, etc.
- An energy peak and valley notifications system.
- Time sensitive alerts that respond to abnormal energy use.

Powerplay
- Tool for setting an energy savings budget.
- Multi-unit comparison tool (showing ranking, notifying users of changes).

Flipswitch
- A tool to help make energy efficient appliance shopping decisions.
- Utility for testing how much individual devices use by monitoring changes in real-time usage.

Powerplay

Money Saving



Compete, but don't communicate; Multi-unit building comparison

Energy Mountain

Peak and Valley; Baseline | *Time of Days; Contextual Notifcations* | *Widgets; Passive/Abstracted*

Flipswitch

Adjusting controls; Real-time usage checking | *Answering contextual questions about appliances and usage*

Additional Insights

Based on the interviews conducted, some additional insights were also noted. These influenced the selection and arrangement of the seven ideas as well as the later prototype development.

- Users want information that tells them "what to do" about their power consumption. They want actionable insights, in addition to visualizations and charts.
- Users like comparison, but not necessarily communication between friends and teams.
- Sharing achievements on social networks is desirable.
- Users want to know if their energy consumption falls under a usual or acceptable range.
- Controlling appliances remotely (switching on/off) from a smart phone is exciting for potential users.
- Applications that require constant involvement and time did not appeal to users. Users enjoy something that runs in the background.

Low-Fidelity 3 Concepts

PAPER PROTOTYPE

The three concepts from speed dating were made into low fidelity paper prototypes. The primary focus was to test the basic interface, features and information architecture.

9 PARTICIPANTS
7 women (28-39 years old)
2 men (37-42 years old)

28 32 37
29 34 39
31 37 42

Process

After coming up with three concept ideas (EnergyMountain, Flipswitch, Powerplay), each member of Team Silk sketched their individual vision of the concepts on paper. These sketches were then discussed and key features combined to create a low fidelity interface design for each of the concepts.

Mockups by Balsamiq was used to create low-fidelity digital versions of the designs. The Balsamiq prototypes were then printed out on stock paper and the designs were tested with users in shopping malls and residential neighborhoods.

The tests were conducted as a combination of speed dating and think-aloud usability test. Users reviewed the paper prototypes and their reactions, favorite and least favorite concepts and features were recorded. Team Silk analyzed the user feedback and identified overall favorite concepts and features as well as problem areas.

Outcome

Based on this early testing, feedback from users was generally positive for Flipswitch, slightly less so for Powerplay, (largely due to privacy concerns) and generally negative for Energy Mountain, as users struggled to identify with the traffic widget for showing abstracted energy use.

What was more important than feedback on overall concepts were pieces of feedback on the features. This would be used to reformulated the three prototypes into two in the next round. More on feedback on feature on the following pages.

ENERGY MOUNTAIN

Design

Energy Mountain prompts users to be conscious of their energy consumption habits through ***push notifications(1)***, energy ***graphs(2)*** that give context to the notifications, and energy abstraction through a ***traffic widget(3)*** that shows more traffic when more energy is being used. The system ***integrates current weather(3)*** and ***user location(4)*** to provide the best possible contextual alerts at any given time.

Feedback

As mentioned, overall feedback on EnergyMountian was negative. It did not perform as well as the other designs and was not a favorite, but users liked several features.

Negative Feedback

- Alerts that show when users are away from home seemed futile as users couldn't take action.
- The traffic widget didn't make sense.
- Users didn't have a way to keep energy widgets up on phones or computers.
- Homemakers and users who stay home did find the application useful.

Positive Feedback

- Finding out expected energy consumption in the future is helpful.
- Users like that the alerts were contextual.

POWERPLAY

Design

Powerplay motivates users by presenting their own and neighbor's data via a ***ranked list(2)***. Users can be added to a group to compete using their address or a team code on the ***settings screen(1)***. By clicking on individuals from the ranked list, users can see ***graphs and charts(3)*** that show how others or themselves are performing relative to their average use. Users can also access a ***list of tips(4)***, which they can use to set a power goal.

Feedback

In general, potential users responded favorably to the novelty of energy based competition, and the ability to see how the neighbors are doing, but they also raised some red flags.

Negative Feedback

- Several users had concerns about privacy and were uneasy about sharing their energy data with their neighbors.
- Users had a hard time finding tips with the way it was included in the interface.
- Concerns about fairness were raised since participants may have differing living situations (number of occupants, square footage, etc.).
- Users felt the app might be too competitive.
- Many users were not interested in a game. They feel like it was targeted at only young audiences.

Positive Feedback

- Users liked the saving tips and energy monitoring features.
- Users like the insight into what others were doing to save energy.

FLIPSWITCH

Design

Flipswitch provides users with the means to see how their home is performing as a whole via a large slot machine style ***ticker and money tracker(1)***. It also allows users to see approximately how much individual appliances are using by testing those appliances in the ***testing screen(2)***. The app also allows users to see ***setting for all devices(3)*** in one place and to virtually test how changes to those settings might impact energy consumption.

Feedback

User feedback for Flipswitch was generally positive. Seven users out of 10 chose it as their favorite concept, though others felt it was overly complicated.

Negative Feedback

- Some users struggled with the process of setting up devices and felt the application was too intense.
- There was a sense among some users that the application didn't have long term value. "Once I set it up, then what?" was a common question.

Positive Feedback

- Users liked the extent of control Flipswitch provided and the real-time, device-level energy data.
- The ticker at the top of the screen was a huge hit.
- Users liked being able to see all of the devices on a single screen.

Refining 2 Concepts

INTERACTIVE 1

After analyzing the results from the paper prototyping and feedback, Team Silk condensed these 3 concepts into 2 new prototypes and rebuilt them in Adobe Fireworks with linked and embedded interactions and a new interface design.

6 PARTICIPANTS
2 women (24-30 years old)
4 men (21-60 years old)

24 21 32
30 25 60

Process

Team Silk took all of the most successful features from the last round back to the drawing board to look at ways to reformulate them. What resulted was a product that built on the social/competitive concept which kept the name Powerplay, and a product that built on the device-level data that took the name CurrentControl.

As with the first round, each team member brought in paper concept sketches which were discussed and merged. The final screens were built using Adobe Fireworks and the Tap toolkit from Unitid to export a clickable, interactive prototype.

The team conducted six users tests in the usability lab at CMU along with two performed remotely. The tests were think aloud style, where participants had specific tasks to complete, and were given minimal help. The results of these tests are at the end of this section. Users were also asked for overall feedback.

Outcome

The user feedback was generally positive for both prototypes during this round, though the feedback seemed to indicate different user bases for the two products or at least different lifecycles. Powerplay was geared toward most novices in terms of energy conservation and consumption, and had the ability to create long term adoption, CurrentControl was more attractive to already motivated conservers, and was geared to more short term and infrequent engagement.

More feedback on the individual designs is on the pages that follow.

POWERPLAY

Design

Powerplay provides users with all the tools they need to understand their real-time energy consumption, and how they stack up against their neighbors, without the details found disturbing in the previous iteration. The interface includes a ***ticker(1)***, much like the previous version of Flipswitch, which can be flipped between kilowatt hours and dollars, and can be used to open a detailed ***comparison chart(2)***. It also has a ***comparison panel(1)***, which can be shifted to show different group, and was created to give and ideal about how neighbors are doing, without showing too much. ***Badges(1)*** were also add as a reward mechanism, and ***tips(3)*** to help users find ways to save. The comparisons were balanced, by collecting data from users on the ***settings screen(4)***.

Feedback

Users said they found this version useful and "cool." It earned high marks, and prompted a closer examination of usability, rather than a functional rewrite.

Negative Feedback

- Users said that they would like to make their own groups with friends, in addition to groups based upon their location or building.
- Text around the comparison chart wasn't clear.
- Tips screen was confusing and complicated.

Positive Feedback

- Users liked comparison with the best, worst and average "values" rather than individual users and units.
- No concerns about privacy.
- Comparing current usage with previous intervals was helpful for users to understand what may be affecting their energy use.

CURRENTCONTROL

Design

The design for CurrentControl focused on developing a robust solution for the interest that users showed in Flipswitch, and specifically in being able to see how their individual devices use energy.

A full treatment of the features of this version of CurrentControl can be found in the Looking Ahead section of this report (Page 76).

Feedback

All but one user reacted pleasantly to CurrentControl. It was sufficiently popular with users to prompt a real debate among Team Silk and Eaton stakeholders. The key problem with the design is something rapid iterations could not account for. The process of gathering data about or from devices is burdensome, and most of the data must be estimated.

Negative Feedback

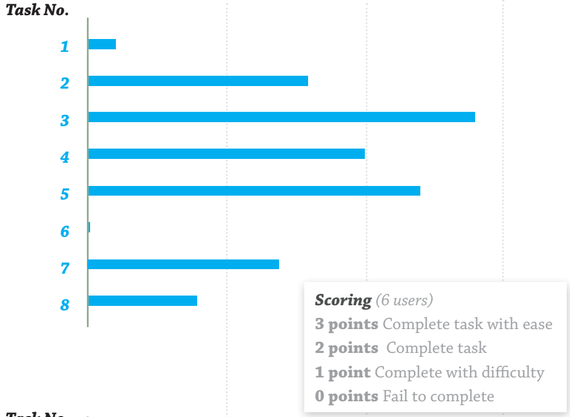
- There were some concerns about the complexity of the app. Users had trouble completing some of the tasks.
- Users had different preferences about the granularity of data in the appliance level chart. Energy savvy users liked to see all the appliances listed, while others preferred appliances combined under categories or context.
- Users found the setting up process a hassle, while motivated users enjoyed playing around with the features.
- Multiple time frames on the screen (monthly ticker/weekly charts) was confusing.

Positive Feedback

- The pie chart was a particularly powerful and novel way for people to see their power broken down.
- Users loved the amount of control they felt like they had.

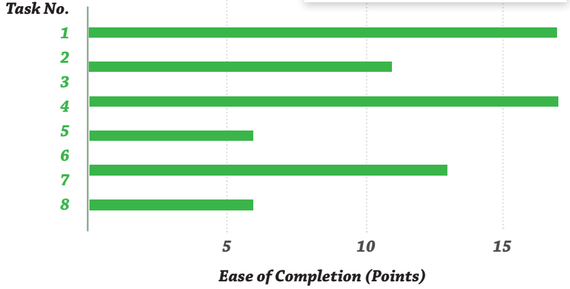
TESTING TASKS AND SUCCESS RATES

1. Identify your rank compared to your neighbors.
2. Identify the amount of money you have spent on energy during the last 7 days.
3. Identify the day this week where you consumed the most electricity.
4. Identify how many of your neighbors have pledged to perform the most popular energy savings tip.
5. Share your the badge you earned for reducing your energy 5% from the previous month.
6. Join a new group for your apartment building to compare your energy use with.
7. Identify your ranking in your apartment building.
8. You want to lower your energy bill and are looking for possible actions to do. Find one that is easy to do and reduces cost.



CurrentControl

1. Identify the proportion of electricity use that heating and cooling consume.
2. Identify the difference between your projected weekly consumption and your actual consumption.
3. Identify the day this week where you consumed the most electricity.
4. Adjust your weekly budget goal.
5. Disable notifications for abnormal energy use.
6. Test your television to verify how much electricity it is using.



Finalizing 1 Concept

INTERACTIVE 2

With the final design direction focused on Powerplay, Team Silk concentrated on creating visual elements of the application while perfecting the interaction design.

5 PARTICIPANTS
2 women (25-39 years old)
3 men (35-41 years old)

25 35 41
39 36

Process

With testing complete on the interactive fireworks prototypes, the decision had to be made on a direction. After some deliberation (see the Looking Ahead section for further discussion on the process) Powerplay was selected as the direction to follow..

At this point prototyping work split roughly in three piece, interactive revisions, visual design and HTML development. Interactive revisions involved incorporating feedback from previous versions of Powerplay into the final as well as ongoing testing with users to review changes. The visual design was completed by creating a mood board of ideas the team felt represented the idea of Powerplay, and building swatch and widget libraries. The code development involved converting what had been designed and tested into something actually interactive, in this case a native iPhone application build using HTML5 and other web standards, and using real, live data from at least four households.

Outcome

There are two final deliverables from this project, which, in theory, work identically, the wireframe screens presented in the design portion of the report and the coded live demo. In practice there are limitations with the coded version, and it shouldn't be taken as a definitive source for the design ideas, but rather as an example of how some of the concepts could live in code and of how some of the interface interactions were designed to work.

While this design is intended to be complete, there are several open issues that merit discussion before Powerplay could go into full development mode. Discussion of these issues is in the Looking Ahead section.

INTERACTION DEVELOPMENT

Design

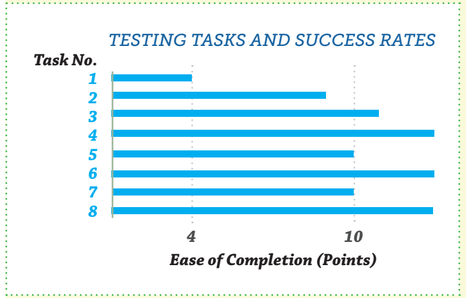
Screens showing off the final interactive development make up nearly the entire Design section of this report. Please see that section for details about the key features and findings.

Feedback

Users were incredibly pleased with the final prototype interaction. They were able to intuitively understand the purpose of the application as well as find the key functions and complete think aloud tasks. A few of issues did surface and were addressed as they came up.

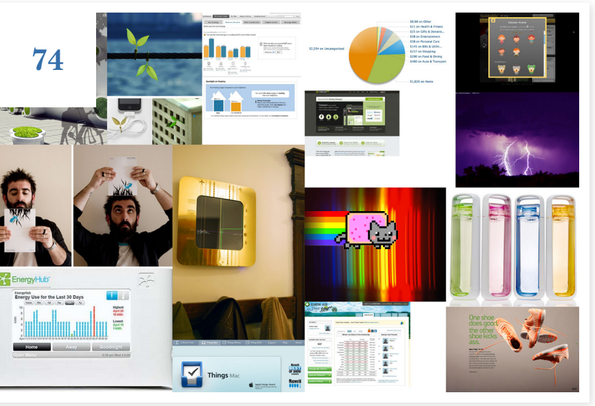
Addressed Issues

- The time frame selector wasn't completely intuitive or highly visible to users, so it was traded for a folder or divider time tab that included the date range.
- Users had a hard time understanding the time frames presented in the application, because there wasn't a consistent sense of time frame from the top header to the graphs below. The dates were streamlined so the entire application changed based on a time frame selected at the top.
- The ticker originally envisioned to motivated users as it ticked off the watts and dollars being used proved mathematically impractical. Because the typical rate of consumption is small, the number would only tick at a rate of once every several seconds. The ticker was replaced with a more static looking display.
- Users continued to struggle with locating information about their rank compared to others and with deciphering text in the comparison box. It was decided that all text would be removed.
- Users tended to want to tap on the comparison graph to get a sense of what level they are and how far they are from others. Later prototype versions accounted for this.
- The tips screen proved confusing to users, so it was dramatically simplified.



1. Identify your rank compared to your neighbors.
2. Identify the amount of money you have spent on energy during the last 7 days.
3. Identify the day this week where you consumed the most electricity.
4. Identify how many of your neighbors have pledged to perform the most popular energy savings tip.
5. Share your the badge you earned for reducing your energy 5% from the previous month.
6. Join a new group for your apartment building to compare your energy use with.
7. Identify your ranking in your apartment building.
8. You want to lower your energy bill and are looking for possible actions to do. Find one that is easy to do and reduces cost.

VISUAL DEVELOPMENT

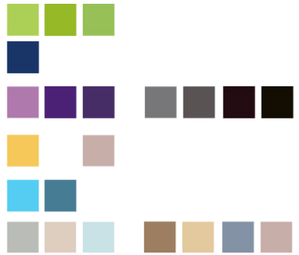


Design

As an introduction to the visual design, Team Silk put together a ***moodboard***, to showcase colors, visual ideas and general aesthetics, that members of the team felt, based on research, would translate well into Powerplay, and connect with the target audience. The mood board was then translated into a ***swatches***, which was a starting off point for what would become the final visual aesthetic. More detail on the exact colors and visual concepts that were employed, as well as the pixel measurements of the various screens can be found in the Appendix of this report.

Feedback

Feedback on the visual design was strongly positive. Users connected with the colors and felt they associated well with energy efficiency and technology.



CODE DEVELOPMENT

Team Silk created a functional prototype to test and demonstrate interactive elements of the Powerplay interface and methods of visualizing energy data. The source code for the functional prototype will be included with other project deliverables and, when rebuilt and connected to properly formatted data sources, will continue to operate as intended.

Addressed Issues

- The database architecture for recording energy history information was originally built in a REST-based document-driven database. However, the lack of true relational organization and the difficulty in creating logical indexes made it necessary to switch to a traditional relational database system.
- jQueryMobile is version 1 beta at the time of this implementation and is quickly become mature. Documentation and examples are limited and the theme architecture is still being heavily developed.
- The HighCharts chart api is robust and extensible, but lacks certain features, such as the ability to render specific content onto graph bars or display color gradients. As a consequence, some charts are dynamically built and rendered in HTML and JavaScript.
- Some features that would require data analysis and further database storage, such as achievements and tips, were not implemented on the back-end for the purpose of the demo, but when connected to an appropriate data source, should display as designed in the functional prototype.

Looking Ahead

With this design in hand...

Eaton has the opportunity to rapidly develop and deploy a product that will create value for energy consumers. This section will discuss specific strategies and logistics related to the development of Powerplay as it has been described. It will also include potential design directions beyond the bounds of what has been previously mentioned.

Team Silk used a methodology on this project that involved developing simultaneous distinct visions (the 3-2-1 Methodology). And, while the Powerplay concept won out, two of these alternative visions merit specific attention and will be treated in some detail in this section. These ideas including creating a commercial sector centric product from Powerplay and developing a separate application or suite of tools focused on showing device-level data.

Implementing Powerplay

Converting a design into a final product involves many factors beyond just the look and function. Below are five considerations, collected as a starting point for the discussion about implementating Powerplay.

Application Platform

The high fidelity prototype delivered with this report was built using HTML5, CSS3 and JavaScript on top of the jQueryMobile interaction framework. The application was then packaged in the PhoneGap application framework to provide access to native Apple iOS APIs. This approach has some advantages in being quick to build and easily portable to other platforms. However, because it is essentially a packaged web application, it suffers from many practical problems and performance issues that would be solved by creating a native application for each intended mobile platform.

Recommendation Team Silk recommends that Powerplay be developed natively for the targeted mobile platforms. This approach will ensure that the app maintains design cohesion and that visualizations, transitions and notifications function efficiently.

Application Datasets

There are several pieces of Powerplay that hinge on well curated and calibrated lists of tips and achievements. Starter samples of these data sets, specifically energy saving tips and achievements are included in the appendix of this report.

Recommendation Working with experts in energy conservation as well as motivation may be necessary to creats meaningful actions and rewards for consumers that will maximize conservation behavior.

Continued Work with Designers and Users

While the work presented in this report is a strong design, it's impossible at this stage of prototyping to anticipate every obstacle, edge case or user requirement that may arise. Each new issue will require a user centered approach to solve.

Recommendation Team Silk recommends that the practice of user experience design be integrated throughout the development process to ensure that the final product represents the strong design thinking that helped to create it.

Meter Connection

Without a connection to users' real-time metered data, Powerplay can not function. The process of connecting a mobile application directly to a smart-meter, however, poses potential challenges. Inputting the IP address of a network-enabled meter, for example, would likely be too complicated for a typical home user and pose a major adoption barrier.

Recommendation The most effective solution to this problem would be to maintain a central database that could match networked meters to addresses or other identifying information and then, through simple verification, synchronize the meter data with the Powerplay application without requiring any outside hardware or software configuration.

Database and Server-Side Development

A key feature of Powerplay is the application's ability to show users all the data they need about their energy in real time and to process data constantly in order to deliver alerts, insights, achievements, etc. A system like this requires a data warehouse and web service to collect historical metering information, analyze it and then serve it back to the application. This type of application will be expensive in terms development and infrastructure and also raise questions about user data security, but will most likely be unavoidable given the architecture of the design.

Recommendation As implementation discussions start to happen, Team Silk recommends pulling in relevant experts in database and server development to review the expected back-end requirements for Powerplay and to help create relevant budgets and time lines.

Powerplay for Business

While Powerplay was developed as a tool for residential users based on research and testing with residents, there are some opportunities to use it in the commercial sector. Just as residents compete against one another, Powerplay could be tailored to allow businesses to compete, either by colocation (all the stores at a shopping mall) or through a corporate network.

As mentioned in the research report, few opportunities for a mobile application for real-time data were found in the commercial sector because store employees and managers saw consumption as operation standards that couldn't be leveraged. After much discussion with Eaton stakeholders, the project was focused on the residential sector.

One exceptional case in the commercial sector came from a corporate energy czar for a major retail chain. He noted that he would love to have a tool to allow stores to compete with other stores on an apples-to-apples basis using normalization across locations. He said while changes are not always possible, there is space for improvement, particularly in off hours when employees are around, but the store isn't open.

A version of Powerplay focused on commercial users would likely require some changes. Depending on the focus, some suggested changes may be:

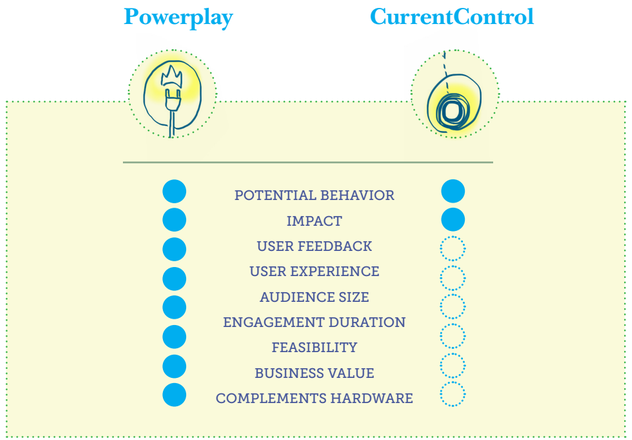
Setting-up A retooled settings page focused on metrics that make more sense at a business. Some type of initial authentication and content tailoring to allow business to set up employee counts exactly as they want them.

Tips/Achievements A new, business centric achievements and tips. It might also make sense to give access to company directors to create their own tips and achievements.

Access Hierarchy An administration panel or web tool to allow users with appropriate clearance to see cumulative data across stores.

Considering CurrentControl

When moving from two to one prototypes, Team Silk debated between Powerplay and CurrentControl. Powerplay, as noted throughout the report, is focused on real-time data and social competition. CurrentControl is focused on another key insight discussed in the spring report: displaying device-level data. Both had their merits.



The decision between the two concepts was broken into eight categories. The first four, potential behavior impact and user feedback deal specifically with direct impact of the concept, and in these, both ideas scored well. To make the decision, however, Team Silk added two additional groups of factors.

Engagement duration and user experience, were ideas hinted at during user testing, where users showed a lack of interest in CurrentControl for long term use and because user expectations were that the disambiguation data they were shown was accurate and real time. In both of these areas, Powerplay was the clear winner.

Four other concepts were also added to the discussion that related to the practicality and potential reach of the ideas, these included audience size, feasibility, business value and complementing Eaton hardware. In all of these areas Powerplay won out because the design is for a mobile phone rather than a tablet, which has a broader reach, it is readily implementable in code without extensive data libraries or new hardware, there is a straightforward business case (see earlier in the Looking Ahead section), and because Powerplay could be used to connect users on a multi-point meter, where CurrentControl doesn't have a clear business tie in.

That being said, this result was largely based on the fact that at present most device level data is fake. It's either based on estimates and algorithms, or challenging -to-set-up load profiles. In the end it was judged that the target users would find this process daunting and the data too unreliable to find adequate value in the application.

All of these observations could change as technology became available to handle some of this tracking. Two advancements in hardware could CurrentControl much more interesting and valuable:

1. Devices embedded with communication technology. This is already starting to become more popular with in-home Zigbee wireless networks where appliances with embedded radios can broadcast usage information.

2. Plug monitors. Companies like Energy Hub are doing home monitoring via plug sensors. They are used to detect electrical flow, but can also be used to turn off devices individually.

As these technologies and others become more popular they may improve the feasibility and potential reach of a an application targeted at device-level data, which is why the features and medium fidelity designs that went into CurrentControl have been included on the following pages.

CurrentControl

CurrentControl went through two rounds of prototyping including user testing and refinements. The application includes features such as alerts, an energy header, energy in dollars and kilowatt hours, and detailed usage graphs. It also included the following additional features.

1. Device Level Data

The key component of CurrentControl was giving users access to their real-time device data. Studies have shown this can reduce consumption significantly. The interface shows the data in a pie chart grouped by category. Users can access a detailed screen and see what devices are associated with each category.

2. Tablet Form Factor

While the design may be scalable to a phone, because of the additional data required for individual devices it was decided to build CurrentControl for the tablet which is gaining in consumer popularity.

3. Goal Setting

Given the technical nature of the application, the focus of the design was on a different user persona than Powerplay. The CurrentControl user persona ("Margaret" from the research report) is both environmentally aware and cost conscious, so the application includes a budgeting tool. The user can set a goal that impacts both the daily and monthly cumulative usage totals. The user is then alerted by the application if they are not on track to stay within the budget.

4. Cumulative Consumption Graph

Because CurrentControl users are expected to spend time budgeting monthly spending, a cumulative consumption graph was included. This allows users to see a clear monthly goal and view whether they appear on track to achieve it.

5. Device Testing

Because a restriction on the scope of the project was that all data would be coming from a whole-home, real-time stream, the device testing pages were created as a tool for users to create their own device data by testing the change to the whole-home energy consumption when devices are turned on. Many questions arose in testing this component, and not all were settled before the prototype direction was abandoned. Looking at how devices would be entered into the system would be a good starting place for any design efforts related to CurrentControl.

Appendix

Technical Implementation

The creation of a functional prototype was essential in providing a platform on which to test the feasibility of the design, navigation, interaction and technology of the Powerplay application.

Hardware Requirements

While a network-enabled multi-point meter would make the collection and aggregation of large amounts of energy data simple, Team Silk did not have access to such advanced hardware. Instead, the team installed several The Energy Detective (TED-5000) home metering systems into residences around the Pittsburgh area. The Energy Detective requires a set of current transformers (CTs) be installed into the main breaker box of the residence and then connected to a transmitting unit. The transmitted data is received by a network-enabled gateway that stores and hosts the data for real-time retrieval and display.

Through a built-in XML-based API, accessing historical energy data proved to be straight-forward process. Combined with other publicly accessible residential TED systems, Team Silk was able to amass six data sets for comparison and display in the functional prototype.

Database and Web Services

Powerplay provides users with the ability to simply and quickly compare themselves to others in their groups. While each users' data is accessible from their metering system, having to query each individually networked meter to perform each comparison would be too network intensive and prone to failure. Therefore, in the functional prototype, historical energy data for Powerplay users is stored centrally in a database for quick access and simple comparison. The database architecture is relational, requiring tables for users, groups and records of time-stamped energy readings at hourly, daily and monthly aggregates. A simple Python script accesses the historical data feeds from each metering device at hourly intervals and records any new records into the centralized database.

A Python-based web service written on top of the Flask framework serves JSON-encoded data to the Powerplay application to be rendered into graphs and live data tickers. The web service computes minimum, maximum and average values from the requested user group and sends it along with hourly, daily or monthly interval information for any available date range that the application requires. "Live data" is relayed through the service from the networked meter, requiring polling of the metering device about once per second. The live values are parsed by the web service and served to the application.

Mobile Application

The functional prototype of the Powerplay application is programmed in a combination of HTML5, CSS, and JavaScript on top of the jQueryMobile framework. The jQueryMobile framework provides a set of widgets, interactors, themes, transitions and application glue that make creation of mobile web applications simple and fast. Coupled with the PhoneGap native application framework, Powerplay gains access to native Apple iOS APIs that enable features such as push notifications and local storage.

Team Silk chose the Apple iOS platform, specifically the iPhone, for implementing interactive and functional prototypes for a number of practical reasons. The install base of iOS devices in the United States is very large and encompasses a wide demographic of users both technical and non-technical. Also, the iOS platform has a well developed library of recognizable navigation widgets and standard interactions that add realism and aesthetic to the prototype. Finally, the variability between iOS devices is far less than in other smartphone ecosystems and designs need only be tailored to a small number of potential well-supported devices."

Application Documentation

Powerplay Logo
Chalet, 24px

Energy Display Header
Helvetica, Bold, 14px
$ - Helvetica, 24px
kWh - Helvetica, 18px

Current Display Header
Helvetica, Bold, 12px
$ - Helvetica, 24px
kWh - Helvetica, 20px

Headers
Helvetica, 12px, Uppercase

Labels
Helvetica, 10px

Text
Helvetica, 14px

Navigation
Helvetica, 10px, Bold, Lowercase

Time Frame Header
Helvetica, 14px, Bold, Embossed

Number
Helvetica, 24px, Bold, Embossed

Powerplay Logo
Blue #00ccff, (0,204,255)
White #ffffff, (255,255,255)

App Background
Dark Blue, #1c2566, (28,37,102)
Grey Blue, #457c94, (69,124,148)

Circle
Grey Blue, #457c94, (69,124,148)

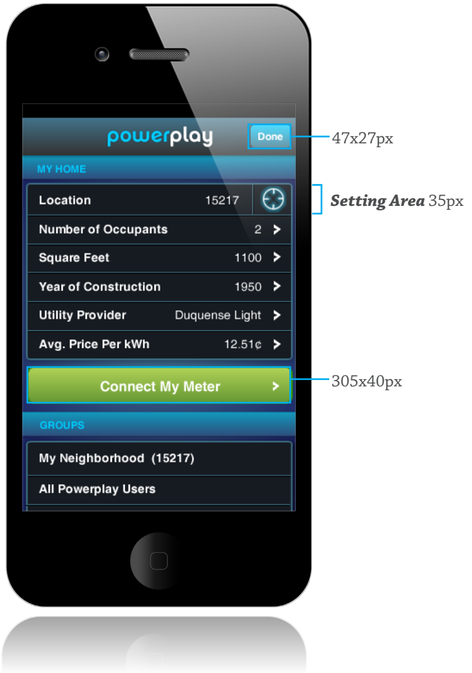
Crown
Blue #00ccff, (0,204,255)
White #ffffff, (255,255,255)

Plug
Yellow #fcfe58, (252,254,184)
Yellow Green #457c94, (171,205,85)

Content Background and Border
Almost Black #161b21, (22,27,33)
Grey Blue, #457c94, (69,124,148)

Section Header
Muted Blue #1297bb, (18,151,187)
Muted Royal #2e517e, (46,81,126)

Navigation Background
Dark Grey #212121, (33,33,33)
Black #000000, (0,0,0)



Application Databases

Ranking

Rank is assigned to a user based on performance in each comparison group. Rank may be a percentile (Top 10%) or number (3 out of 25).

If the group is a location based group ("My Neighborhood"), where the energy data generated is disambiguated, rank will be in percentile, since the number of group members may be large.

If the group is custom created ("Powerplay Friends") then rank will be expressed in number.

Based on the rank, user will be assigned either crown or smiley face.

RANK (%)	IMAGE
Best (1%)	Diamond Crown 
Top 10% (2-10%)	Gold Crown 
Top 20% (11-20%)	Silver Crown 
Top 50% (21-50%)	Bronze Crown 
Below Average (51-80%)	Yellow Frown 
Bottom 20% (81-99%)	Orange Frown 
Worst (100%)	Red Frown 

Energy Saving Tips

TIPS	COST	EFFORT	kWh SAVED / MONTH	kWh SAVED / YEAR
1. Replace all light bulbs with lower wattage CFLs.	*low*	*low*	***5.36***	***64.32***
2. Use task lighting instead of overhead lighting.	*med*	*med*	***2.2***	***26.4***
3. Install photosensitive LED night lights in the house.	*med*	*low*	***10% less***	***10% less***
4. Use solar energy powered outdoor lighting.	*med*	*low*	***50%***	***50%***
5. Wash only full loads of clothes.	*none*	*low*	***1***	***12***
6. Air dry clothes.	*none*	*high*	***1.3***	***15.6***
7. Clean the lint screen after each load of laundry.	*none*	*low*	***30%***	***30%***
8. Upgrade to energy star appliances.	*high*	*med*	***40%***	***40%***
9. Use an appliance timer on air conditioners.	*low*	*low*		
10. Raise the set temperarure for the air conditioning in the home while out.	*none*	*low*	***5.35***	***64.2***
11. Use space heaters to heat occupied rooms and turn off the heat while out.	*med*	*low*	-	-
12. Use door draft guards.	*low*	*low*	***20%***	***20%***
13. Install a programmable thermostat for the whole house.	*high*	*med*	***166.7***	***2000.4***
14. Upgrade to energy star windows and doors.	*high*	*low*	-	-
15. Replace the home's HVAC filters.	*med*	*med*	***12%***	***12%***
16. Use smartstrip power strips for devices on standby or devices that have digital dislay.	*low*	*low*	-	-
17. Insulate water heater and water pipes.	*low*	*med*	-	-
18. Install efficient shower heads.	*low*	*med*	-	-
19. Install a faucet aerator in warm water supply.	*low*	*low*	-	-
20. Get an energy audit/energy efficient home certification.	*high*	*high*	***30%***	***30%***

Achievements

Battle Royale

"You created an adhoc group."
Condition User created a custom group and invited at least two people to join.

Play with Friends

"You recruited 5 friends."
Condition User recruited 5 friends to use the Powerplay application.

Keeping Cool

"You successfully reduced your overall usage by 5% on a hot day."
Condition User reduces usage by 5% on day which the temperature is at least 85 degrees.

Sweating It Out

"Your power usage has gone down by 10%+ on a hot day."
Condition User reduced consumption by 10% when temperature was at least 85 degrees.

Power Promoter

"You shared 3 badges."
Condition User shared 3 achievements on any social network.

Raining Savings

"Your power usage has dropped 2% every week for 5 straight weeks."
Condition User reduced consumption by at least 2% for 5 consecutive weeks.

Tipping Point

"You added 5 new tips to My List."
Condition User commits to a 5 tips.

On the Rise

"You have been consistently reducing consumption over the past half a year."
Condition User has been ranked above average for the last 6 months in at least 2 groups.

Bright Owl

"You successfully reduced your power usage at night by 10%."
Condition User reduced consumption by 10% between the 8pm-6am during the last 2 months.

Power Player

"This is your fifth login in a row."
Condition User logged into Powerplay five days in a row.

Pimp Player

"This is your 20th login this month."
Condition User logged into Powerplay 20 days out of the last 30 days.

Power Champ

"You have been above average for the past month."
Condition User's consumption has remained above average in at least one group for the past month.

Power Pro

"You are now performing the best."
Condition User's consumption is the best in at least one group.

Power Boss

"You have been the best in your group for the past 2 weeks."
Condition User's consumption has stayed the best for 2 weeks.

10 for 7

"Your consumption improved by 10% this week compared to last week."
Condition User reduced consumption by at least 10% compared to last week.

10 for 30

"Your consumption improved by 10% this month compared to last month."
Condition User reduced consumption by at least 10% compared to last month.

Earth Day 2011

"You switched off all lights for an hour on the Earth Day 2011."
Condition User's consumption dramatically reduced during Earth Day for at least an hour. Limited edition badges like this may be added annually.

About the HCII

The Carnegie Mellon University Human-Computer Interaction Institute is an interdisciplinary community of students and faculty dedicated to technology which enriches human experiences. The Master's program is a rigorous 12 month curriculum which students complete coursework in programming, design, psychology, research methods and electives which allow them to personalize their educational experience. During their second and third semesters, the students participate in a capstone project with an industry sponsor.

The capstone project curriculum is structured to cover the end-to-end process of a research and development product cycle, while working closely with an industry sponsor on new ideas or applications. The goal of this 32-week course is to give each student the opportunity for a "real-life" industry project.

Company sponsors benefit from innovative ideas students produce with solutions that to fix existing systems or reach new markets. Some companies also use this project as a recruiting tool, offering industry positions to the top producers.

For questions about the program or to learn how to sponsor a project contact:

Jenna Date, Director of MHCI

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412.268.5572

Human-Computer Interaction Institute
Carnegie Mellon University
Pittsburgh, PA

Team Silk

David Randall
Project Team Lead

David is efficient. After studying journalism and economics at Brigham Young University and working for a daily newspaper, David entered the world of healthcare IT, working for Epic in Madison, WI. His work there brought out a keen interest in software design, which after a stint for a mobile app start-up, Nevercenter, led to Carnegie Mellon.

Susan Lin
Design Lead

Susan is inspired. Susan just completed her interdisciplinary degree in Information Systems and Fine Art at Carnegie Mellon. Last summer, she had the pleasure of crafting user experiences with LinkedIn in Mountain View, CA. In addition to interfaces, she has a thing for cute and makes indie games, usually featuring cats.

Bhavana Gupta
User Research Lead

Bhavana is empathetic. In addition to a Bachelors degree in Computer Science from MITS, India, Bhavana is a Certified Usability Analyst (CUA by Human Factors Inc.) She worked as a Usability Engineer before coming to Carnegie Mellon.

Mark Shuster
Development Lead

Mark is adaptable. Upon completing a degree in Japanese studies at the University of Michigan, Mark promptly switched careers and moved to New York City. Before coming to Carnegie Mellon, he worked in the non-profit sector, doing front-end web development for AJWS, an international development organization.