Deriving Age Diverse Personas from a Participatory Design Study on Home Electricity Feedback

Jonathan Dodge
Oregon State University
1148 Kelley Engineering Center,
Corvallis, OR 97331
dodgej@oregonstate.edu

Josie Hunter
Oregon State University
hunterj@lifetime.oregonstate.edu

Michael Hilton
Oregon State University
hiltonm@oregonstate.edu

Karl Smeltzer
Catharina Vijay
Oregon State University
smeltzek@oregonstate.edu
vijayc@oregonstate.edu

Ronald A. Metoyer
Notre Dame University
384 Fitzpatrick Hall,
Notre Dame, IN 46556
rmetoyer@nd.edu

Andrew Atkinson
Oregon State University
atkinson@lifetime.oregonstate.edu

CHI'17 Extended Abstracts, May 06-11, 2017, Denver, CO, USA

http://dx.doi.org/10.1145/3027063.3053354

Abstract
Eco-feedback technology is generally concerned with the communication of information to affect individual or group behavior with respect to environmental impact. Electricity consumption feedback, in particular, has been studied from various viewpoints to understand its effects on consumption behavior and to explore the design space. Recent efforts have resulted in a wide array of device designs ranging from individual appliance feedback at the outlet to centralized devices for home consumption awareness. However, adoption rates for these technologies remain relatively poor, perhaps due to a lack of emphasis on specific user needs. In this paper, we contribute a participatory design study to examine differences and similarities among three targeted household demographics: older adults, families with children, and students in shared housing. In addition, we present our process for extracting personas from participatory design study data, alongside the set of resulting persona skeletons and one finished persona.

Author Keywords
Participatory Design; Personas; Electricity feedback; Age; Sustainability; Visualization

ACM Classification Keywords
D.2.1 [Requirements/Specifications]: Elicitation Methods; H.5.2 [User Interfaces]: GUI

Figure 1: A distributed system design based on light switches. The line graphs at the top show the time series consumption of the room and the whole house. The green squares on the left allow the users to observe the consumption of the outlets in the room, as well as toggle them. Design by ST1.

Figure 2: A framed picture shows a digital, customizable image. The dominant color signifies low (blue), average (green), or high (red) electricity usage. Design by ST3.

Introduction and Related Work

Residential buildings account for 22% of the energy demand in the USA, rising 23% over the past decade and expected to rise another 25% by 2030 [11]. A number of factors drive this demand, including governmental energy policy, utility companies, and social practices [10, 25]. The bulk of research in eco-feedback, however, has focused on the challenges of individuals and households [8].

Eco-feedback has been a heavily researched field, with a number of products on the market already, however, none have achieved widespread adoption. In addition, the studies examined by Ehrhardt-Martinez et al. [11] had poor participation rates (5-10%) for those using an opt-in design. It has been noted that eco-feedback design often lacks a central focus on real users and their needs, and clear reasons for design decisions [13, 14]. Households vary widely and more recent surveys continue to identify a lack of research on, "the effect of feedback on consumers in different demographic groups" [30]. In this work, we have chosen age diverse demographic groups for two reasons. First, there are strong consumption differences based on family composition [7]. Second, previous research has shown that existing systems have limited impact beyond dads [23, 26].

Personas provide a mechanism for presenting user analysis in a reusable manner for future design problems. Originally, they were seen as a way to *do* participatory design (PD) because the persona kept the user in the minds of the development team and increased engagement [16]. However, personas can also be viewed as the *result* of doing PD. If representative users are engaged in the design process, then persona elements can be extracted *from design process and artifacts directly*. By combining our PD data with demographic research data, we can create a substantiated foundation document, leading to a credible persona.

Brynjarsdóttir et al. [8] reviewed papers written from 2009 to 2011 which related to sustainability, arguing for more user inclusion in the design process, having found only 3 of 36 papers made use of PD. Previous eco-feedback papers that used PD each addressed a distinct setting for consumption reduction, and included a set of participants appropriate for their focus. Miller et al. [18] worked with students to design ways to encourage waste reduction on a college campus . To reduce energy consumption in the workplace, Foster et al. [15] met with business professionals to brainstorm ideas and discuss potential problems and implications. Shrubsole et al. [22] focused on designing home electricity monitoring systems with families and their children. It is critical to acknowledge the restricted context the aforementioned studies examine, as it can cause significant changes in perspective. For example, Foster et al. [15] were focused exclusively on the workplace, and ignored aesthetics.

Although there is a clear link between PD and personas, the techniques have rarely been combined. Additionally, when they are combined it is often the case that the participant and researcher collaborate to build the persona directly [20, 29]. This contrasts with our work, where we use the PD workshop data and artifacts to create personas after all workshops are concluded. In this paper, we make two primary contributions. First, we present the data from our PD study, in the form of quotations and Figures 1-6. Second, we provide a set of personas, based largely upon our PD data, to help eco-feedback designers to improve user focus and communication.

Method and Participants

Though our participants do not have previous experience with eco-feedback technology, they do have experience with minimal electricity feedback (i.e. monthly utility statement). In addition, they know their household dynamics, routines,

RQ1 What is the range of user attitudes and behaviors surrounding electricity consumption given an age diverse demographic population?

RQ2 How can we effectively capture and convey these attitudes and behaviors?

Table 1: Research Questions for this project.

Tag	Participant age + gender		
ST1	18-25M	18-25M	
ST2	18-25F	18-25M	
ST3	18-25F	18-25M	
ST4	18-25F	18-25M	18-25M
FM1	36-45F	18-25M	11-17F
FM2	46-55F	11-17F	5-10F
OA1	55+F	55+M	55+M
OA2	55+F	55+F	55+M
OA3	55+F	55+M	55+M

Table 2: Demographic information for households. Note that participants are evenly split with respect to gender. We will use the "Tag" given here to refer to our groups while discussing results (ST = student, FM = family, OA = Older Adult).

and opinions about whether the feedback is understandable. We examine two research questions shown in Table 1. To answer **RQ1** we designed the PD study discussed in the next two sections. Ultimately, the lessons we learned from examining **RQ1** need to be available to designers and developers, which leads us to **RQ2**. We have chosen to use a set of personas to convey the results of our research.

We held a series of three PD workshops in a home-like setting that was intended to help contextualize the task of designing a device for their own homes [19, 6]. A total of 24 participants each attended one workshop, with a total of three workshops conducted. We worked with nine students from three homes, six family members from two homes, and nine older adults from six homes. We recruited from campus courses, as well as from the participants of a previous field study and then employed snowball sampling. Further participant demographic information is provided in Table 2, along with reference tags for each household.

Each participant was compensated $80 for around five hours of design activities, done in three small groups of 2-3 participants from a single demographic and a researcher to answer questions and prompt the participants to clarify or expand on their ideas. Each activity followed a similar structure: brainstorm designs in small groups, present to the larger group, and discuss the ideas.

Activity 1: Representation and Location
First, we wanted to discover *how* and *where* participants might want their electricity data represented. To provide context, some examples of current technologies were presented. To compare designs for centralized feedback systems with distributed ones, we requested that they consider both designs. We consider distributed systems to consist of many devices, while centralized systems only have few.

Activity 2: Goal Setting and Progress
Second, we asked participants to extend their designs from the previous activity to allow for goal setting. Our intent was to observe how participants might input goals into the system. We prompted them to consider long term goals that stretch over months or years, as well as short term goals only taking days or hours. Participants considered targeting specific appliances, rooms, specific consumers, behaviors, or usage for the entire household. Additionally, participants added communication of goal progress to their designs.

Analysis Methods
Our analysis of the PD study data sought to identify common or unique ideas within each design and compare designs across demographic groups. To do this, we photographed all of the designs and identified general themes using an affinity diagramming process [5] and we reviewed the recorded audio for each design session. We then used an open coding approach to associate themes with each of the visual design artifacts.

After completing the analysis of our data, we followed a process similar to Adlin and Pruitt [2] to create our personas. First, we sought a great deal of new sources to augment the data from our workshops, focusing on demographic data sources [12], and behavioral studies [3, 17]. Next, we built the four persona skeletons shown in Tables 3 and 4. The FEMALE PARENT skeleton was prioritized highest by stakeholders, so this is the full persona we present here.

Results

It is important to keep in mind that our tasks were designed to produce a variety of design ideas, so participants were not given extensive time. Thus, the designs are incomplete, however, taken together with the recorded conversations, we learned a great deal about their preferences.

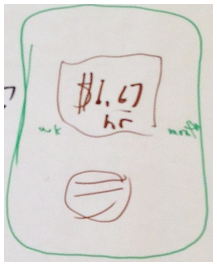

Figure 3: Distributed system intended to compare appliances with newer versions available on the market. The device is intended to be connected between the appliance and the outlet. Then, the display will show the cost per hour of running the device. Design by OA3.

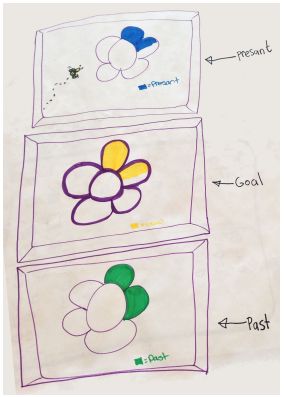

Figure 4: Three flowers help track progress toward a goal by showing present household usage, the goal amount, and past usage. Design by FM2.

Activity 1: Representation and Location
The most common design for the distributed device was a light switch, used by all but ST3, ST4, and OA3. Some of these designs, such as Figure 1, were intended for numeric feedback, while others were more abstract. The ST3 group offered an abstract digital picture frame (Figure 2), while ST4 provided an idea for a platform holding a houseplant which moves up and down to indicate changes in consumption. OA3 designed a device to be connected to an appliance, showing its consumption rate in dollars (Figure 3). The intent of this design was to get, "*as close to the actual use of the electricity as I can get*" (OA3) in an effort to compare the cost of using their appliances with a newer model.

Most of the distributed systems designed by our participants could be categorized as ambient devices. Participants frequently expressed a desire for, "*...something I just walk past and see 'Yeah, thats high or low*"' (ST4) or "*...a small thing in each room, it's like a reminder*" (FM1). Perhaps that is why light switch designs were so common, as ST2 observed that they are located near the entrance/exit and are present in each room already. In addition, a person using a light switch is already interacting with electricity. Last, light switches are positioned close to eye level (OA1).

The most common design for the centralized system was an enhanced thermostat, because it, "*... is the main place you go where you are thinking about energy. Also, it is usually already a panel with buttons and displays.*" (ST1). Another advantage the thermostat has is its location, "*...in the hallway where we always travel*" (FM1). However, it also has drawbacks since some houses may have many thermostats, "*In our house, we have 9 separate thermostats*" (OA3). Other locations that were considered include (in frequency order): mobile application [24], wall mounted tablet, TV [21], by front door, fridge, bathroom mirror, breaker box, and home office. Our participants tended to position a centralized system in meeting places and other high traffic areas, "*large flat surfaces where you go a lot*" (ST4) or "*where you go every day, that, for me, is email*" (OA1).

While the distributed designs were simple one-screen displays, the centralized designs were more complicated and information rich. One of the disadvantages of the extra information is that privacy becomes more important. No participants expressed concern about privacy when discussing the distributed system. Instead, they drew motivation from it, stating "*If I'm embarrassed about it, I should change something*" (FM2), "*It would be an incentive to keep [usage] down*" (ST1) and "*I think it would be good for other people to see it, it would encourage us, it would encourage them*" (OA2). Additionally, OA1 saw the device as a conversation starter. In contrast, when discussing the centralized system, three groups (ST2, ST4, OA3) expressed privacy concerns.

Activity 2: Goal Setting and Progress
The most common type of goal was a *% reduction*, referenced by all groups besides ST2 and ST4. Second most common was a *target value*, typically expressed in dollars, but sometimes in kilowatt hours (ST1, FM1, OA1, OA2). Infrequently, we observed what we call an *"activity goal,"*. Examples include, "*each day, ... remember to turn your light off" (FM2), "Use less hot water*" (FM1), and "*Not to have the lights on where there are no people*" (OA3).

One of the advantages of % reduction goals is that they are well defined regardless of current power costs. As OA1 observes, "*you can't just say 'save money,' might not even be able to do that... they might just raise the price.*" In addition, %-based goals are appropriate for any current consumption level, e.g., "*One room might have more windows and the person in the basement might need the lights on. % kind of levels out discrepancies between rooms*" (ST3).

Figure 5: A candle generates two scents, roses if the power consumption is low and cinnamon if consumption is high. These two scents were chosen because neither is bad, but they are noticeably different. Design by FM1.

Figure 6: On the rightmost column, a % based goal can be specified. After doing so, the goal is shown as a dotted line going across each row. The first row is the total consumption, in terms of dollars, while the rest of the rows are appliance specific information. The columns track progress toward the daily, weekly, monthly, and yearly goals. Design by OA1.

Progress

Participants very frequently used a progress bar to track progress toward a goal, with Figure 4 providing an abstract example. Some groups considered providing an audio alert if the goal was in jeopardy (ST4, FM2, OA1, OA2), while others preferred a flashing color to serve as an alert because sounds might be annoying (ST2, FM1). Those that favored audio alerts mentioned that they are successful at getting attention, like a smoke alarm. A sure way to get the users' attention is by generating a scent, as explored in Figure 5.

Temporal Granularity

If the duration specified for a goal is too short, the user may become annoyed, "*every day would get old pretty fast*" (ST3). Additionally, "*you need more appliances and time to observe an effect of sufficient magnitude to care*" (ST4). However, if the duration is too long, goals may be forgotten or, "*If we only do year by year, it will be useless for the first year*" (ST3). The most common duration for goals was a month, chosen to be the same as the billing cycle (ST2, ST3, ST4, FM1 FM2, OA2). However, there was significant desire for daily or weekly goals, with FM1 noting, "*I think you do want a shorter, weekly goal, so you can make a change before the end of the month.*" Figure 6 shows a design that allows for specification of goals at multiple granularities.

One workaround for cumbersome goal specification is automation, "*set a goal for a month and not have to set a new goal for next month*" (ST1). Also, Participants felt ill informed to specify a feasible goal, stating, "*I personally don't even know where you would start setting a goal, I'd have to look at past bills*" (ST4) and "*base goals on past year usage, because we didn't know where to start, whether it would be realistic*" (OA2). Participants considered using the following data to automatically set goals (in frequency order): previous month, same month of the previous year, an informed guess made by the installer, and a national average based on a similar house. Several participants noted that an important feature of using the first two options is that they account for seasonal change in power consumption.

Use of Abstraction

We found some marked differences in *how* abstraction was used among the demographic groups. The student households used it for aesthetic reasons, making statements like, "*I'm not going to want some boxy mechanical thing, I want something that goes with [the room]*" (ST3). On the other hand, most of the family groups used abstraction so that the children could understand and interact with them. As a parent in FM1 put it, "*[the children] probably aren't going to get up and look at this, so having it just that easy visual is good.*" Previous research has noted that a child-accessible interface is important [28]. Figures 4 and 5 show two abstract designs from our family groups, but their other designs included a pattern-changing carpet and decorative plate, as well as a color-changing stuffed animal.

What-If Scenarios

Several participants wanted concrete suggestions from the system on ways to improve. E.g.: "*If it knows temperature inside and outside, how much could you save by turning the heat down 1 degree, or turning it off at night*" (ST1). "*If I got up half an hour earlier and made my toast, I would save 5 cents*" (OA3). Both of these quotes describe an easy change to a negotiable behavior and connect it to a quantifiable result. This is very similar to the "what-if" scenarios described by Costanza, et al. [9], but is not restricted to simply eliminating an action. As OA3 put it, "*Not many people can process this kind of information and come up with a conclusion... an app which takes all the data and comes up with suggestions, I think that will apply to many more people.*"

Skeleton 1 - MALE RETIREE (age 68)
1. ● Primarily motivated by saving money
2. ● Low computing efficacy
3. ☐ Lives alone (per capita usage is high and privacy settings are not needed)
4. ☐ Large amount of time at home
5. ☐ Possesses potentially outdated appliances
6. ▷ Thinks his household is energy efficient
7. ▷ Little experience with existing energy feedback solutions
8. ▷ Habits are entrenched, needs strong reasons to change

Skeleton 2 - FEMALE PARENT (age 37)
1. ● Primarily motivated by environmental concerns
2. ● Medium computing efficacy
3. ☐ Lives with husband, two kids, and a dog
4. ☐ Works outside of the home
5. ☐ Home is new construction, with energy efficient appliances
6. ☐ Wants to shape good habits for her children
7. ▷ Likes to compare energy usage with others
8. ▷ Willing to make behavior changes to cut carbon emissions

Table 3: Persona skeletons 1 and 2. Each is given a gender, occupation, age, primary motivation, and attitude about their own efficacy. The ☐ is used to denote a piece of household demographic information, while the ▷ is used for information affecting the persona's behavior change disposition.

Discussion

So far we have largely focused on similarities between our demographic groups. Since differences were most important when constructing the skeletons, each section here will directly refer to a skeleton.

The Units Problem

Previous research has observed that householders may have trouble understanding resource management units, preferring visual analogies, such as buckets of water [27]. FM2 made no reference to display units and was the only one to not mention monetary output, choosing to monitor activity goals. OA1 and all the student groups preferred to have both kilowatt-hour and monetary output.

Another interesting aspect to the units problem is whether to visualize consumption total or rate of change. Some designs made both perceivable, for example, FM1 designed a visualization similar to a mechanical "odometer", displayed in dollars. This design is remarkably similar to old power meters, which OA1, "*used to love to go out and look at the meter and see how fast it moved.*" ST1 and ST3 were unclear what unit to use, but wanted to observe a change if the user were to look at the visualization briefly.

Since we found that some participants expressed comfort with and desire for consumption units, we made the FEMALE ENGINEERING STUDENT reflect this (Table 4, line 7). On the other hand, others explicitly preferred monetary units, like the MALE RETIREE (Table 3, line 1).

Immediacy of Feedback

One of the advantages of a distributed design is that feedback may be delivered more immediately. This was important to FM1, repeatedly emphasizing that even if a centralized system was used, it should also include a distributed component in order to get, "*it to fall through the whole family, having that immediate feedback 'Hey, maybe I need to make some changes right now.*' " There is some justification for a system that incorporates both centralized and distributed components. The immediate feedback of a distributed system is preferable, "*so you do something about it now*" (OA1). However, several participants expressed a desire for the data accumulation that the centralized system designs provided. Specifically, accumulated data is useful to, "*help me figure out a more long term plan*" (ST4).

Since we found that parents were very interested in shaping their childrens' behaviors, the FEMALE PARENT reflects this (Table 3, line 6). Conversely, the fact that the children need this shaping implies that their current behavior may be undesirable, thus the MALE CHILD exhibits wasteful behavior (Table 4, line 6).

Contrasting with abstract designs, a very popular method to track usage was to project the bill given current consumption rate information, "*If you continue going like you are, how much it will cost at the end of the month*" (OA2). The groups that mentioned this type of tracking included ST2, ST3, ST4 and OA2. Notably absent from this list are the family households, possibly because not all members of the household are used to interacting with a power bill. Thus, the MALE CHILD skeleton notes a lack of such experience (Table 4, lines 2 and 7).

Non-Negotiable Behaviors

Cutting power to the whole house if we fail to meet a goal can have negative impacts, such as food spoilage or a frozen pipe. This means that some consumption behaviors are less negotiable than others. As OA3 puts it, "*I want the list of points of use, then I want to rank them as far as what I consider critical applications vs non-critical applications vs frivolous applications.*" Another member of the group was quick to point out that the kids might have a totally differ-

Skeleton 3 FEMALE ENGINEERING STUDENT (age 20)

1. ● Primarily motivated by interest in new technologies
2. ● High computing efficacy
3. ☐ Lives with 4 roommates in a large rental house
4. ☐ Spends many hours after class working in the lab
5. ☐ Does not personally own many of the large appliances, but has a great deal of consumer electronics
6. ▷ Is concerned about each roommate paying fair share of bills
7. ▷ Experienced with consumption units
8. ▷ Habits are malleable (if savings are available, she will work toward them)

Skeleton 4 MALE CHILD (age 12)

1. ● Primarily motivated by social norms (pleasing his parents)
2. ● High computing efficacy (enjoys tinkering, but lacks knowledge)
3. ☐ Lives in an apartment with mom and dad
4. ☐ When not at school, is largely at home
5. ☐ Has some electronics
6. ▷ Dependent on parents' intervention
7. ▷ Unconcerned with electricity bill or the environment
8. ▷ Has very few habits, will often forget to turn things off

Table 4: Persona skeletons 3 and 4. As in Table 3, ☐ is used to denote a piece of household demographic information, while the ▷ is used for information affecting the persona's behavior change disposition.

ent ranking. ST1 and OA2 similarly considered a system to itemize usage to target behaviors that are negotiable. It has been noted that it is important to not just target negotiable behaviors, but also cause users to question non-negotiable behaviors [25]. Since we found such a wide range of attitudes about what behaviors are negotiable, we tried to place each skeleton on a spectrum of how malleable their habits are (Tables 3 and 4, line 8).

Incentives

At least one participant objected to the idea of extra incentives, stating, "*The goal is conservation, but it would show itself as savings*" (OA1). This individual felt that the money saved by decreasing power consumption would be its own reward. Ideas included tax credits (OA1), gift certificates (OA1), or a reduced rate from the power company (ST3, ST4, OA1). The fact that participants look to government and industry policies to incentivize shows the importance of change at a scale larger than the individual [10]. Not all the incentive systems discussed were monetary; ST4 spent considerable time discussing an achievement system. In addition, simply *seeing* the reduction in consumption was cited by OA3 as a source of incentive.

Previous research has observed that, "sources of motivation include, environmental issues, financial incentive, interest in new technologies, dream of self reliance, and social norms" [17]. However, we did not observe "dream of self reliance," so we gave one of each of the observed motivating factors to each of our skeletons (Tables 3 and 4, line 1).

Household Comparison

In general, comparison with the user's past self seemed preferable to comparison with others, as OA1 put it, "*you are trying to beat yourself, not your neighbors. They have a different household.*" While ST3 expressed similar sentiment, some studies demonstrate that social comparisons are an effective means of reducing consumption [4]. Despite the overall mixed results [1], it is clear that social comparison is desired by some segments of the population, so the FEMALE PARENT reflects this (Table 3, line 7).

Appliance Comparison

All three older adult populations expressed a desire for the capability to compare appliances they owned with new ones available on the market. An example design for appliance comparison is shown in Figure 3. It is intended for cost analysis, which contrasts slightly with OA2, who focused on conservation, "*With the appliances I have now, I cannot cut down any more. Do I need to buy a new appliance?*" Since concern for consumption of older appliances was so prevalent among our older adult populations, we gave the MALE RETIREE a similar concern (Table 3, line 5).

Individual Comparison

The student households expressed a strong interest in comparing the usage of individuals within the household. ST1 wanted to see a pie chart with a wedge for each person's consumption, then selecting a wedge would provide usage graphs. The goal behind comparing individuals within a household was to assign blame for wasteful behavior, "*to make people more accountable for their actions*" (ST4). Comparison between rooms was not isolated to the student groups, as FM1 also referenced using it.

In addition, electricity feedback allows households that share the power bill to do so more fairly, with all student groups mentioning that they would use it to determine how much each person should pay. ST3 went on to suggest a competition where the person with the greatest % reduction gets a portion of their bill paid by their roommates. Since individual comparison was so prevalent in student participants, we made the FEMALE ENGINEERING STUDENT exhibit this behavior (Table 4, line 6).

Here, our persona is formatted for brevity, refer to our website to see the document as presented to stakeholders.

Note that the text in *red italics* are aspects of the persona which are customizable to best suit the situation. For example, the persona need not be a *Bank Manager* specifically, but must be employed, preferably with an above average income and predictable hours.

Our full foundation document and other materials are available at: http://research.engr.oregonstate.edu/energyPersonas/.

One of our personas

Below we will provide the detailed description of the persona we created based on the FEMALE PARENT skeleton, *Sophia Harmon*, age *37*, employed as a *Bank Manager* in a medium-sized town

Motivation: Sophia is concerned about her family's power usage because of its environmental impact. Since Sophia makes a good income from her job, she does not worry about her power bill. Sophia wants to be able to monitor her family's energy usage, but is a little concerned that the device will be difficult to understand. *She is not afraid of using technology, but doesn't spend her spare time playing with the latest gadgets.*

Household Demographics: Lives in a *single family home* with her *husband, two children, and a dog.* Sophia's children use computers for their homework, like to play video games, and enjoy watching TV. *Sophia would like to have a centralized view so she can track how much energy is being used in each child's bedroom.* She also wishes to help shape her children with developing good habits in regard to energy usage. Working outside of the home means that Sophia has a limited amount of time to perform household chores, and as such, feels unable to make drastic changes to her energy usage. *Home is new construction, having been designed with energy efficiency in mind. Even though it is equipped with energy efficient heating and cooling, it is a larger home, which increases energy consumption.*

Behavior Change Disposition: It is not always easy to make environmentally friendly choices, but Sophia usually makes an effort to do so. Sophia is willing to make changes in her behavior that lead to less energy usage. However, she feels she needs help identifying the appropriate behavior changes. Does not know enough about electricity to always know what behavior to change. She feels that the vague suggestions from her power company are not helpful enough to her. Likes to compare energy usage with others who live around her. Her friends and neighbors are also environmentally friendly and she is very sensitive to peer pressure. Is willing to discuss her energy usage habits with others in order to discuss issues related to sustainability.

Conclusion and Future Work

We have presented a participatory design study intended to gain insight into diverse user attitudes and behaviors for home energy consumption. Additionally, we presented a persona derived partially from the PD study data, which may be used by electricity feedback designers to improve user focus. Last, it is our hope that our process may be applied to other domains in future work. We believe that a strength of our approach is that it can succeed with very few participants, provided sufficient demographic research is combined with the PD data to support generalization.

For future work, we would like to complete foundation documents for each persona skeleton presented. After preparing a complete set of personas we intend to make them available to eco-feedback designers and developers. Another future work possibility is to validate and evaluate our persona by performing a field study within an organization that might benefit from using it. Alongside this effort, we would like to try to determine general guidelines for the process of extracting a persona from PD data.

Acknowledgments

This work was supported by the National Science Foundation (NSF IIS-1018963). We would like to thank our study participants for their willingness to engage in our project, and for taking time out of their weekend to do so. We would also like to thank Oregon State University's Sustainability Center for providing use of their space for our workshops.

REFERENCES

1. Wokje Abrahamse, Linda Steg, Charles Vlek, and Talib Rothengatter. 2005. A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology* (2005).
2. T. Adlin and J. Pruitt. 2010. *The Essential Persona Lifecycle: Your Guide to Building and Using Personas*. Elsevier Science.
3. Hunt Allcott. 2011. Social norms and energy conservation. *Journal of Public Economics* 95 (2011). Special Issue: The Role of Firms in Tax Systems.
4. Ian Ayres, Sophie Raseman, and Alice Shih. 2009. *Evidence from Two Large Field Experiments that Peer Comparison Feedback Can Reduce Residential Energy Usage*. Working Paper 15386. National Bureau of Economic Research.
5. Hugh Beyer and Karen Holtzblatt. 1997. *Contextual design: defining customer-centered systems*. Access Online via Elsevier.
6. Jeanette L. Blomberg and Austin Henderson. 1990. Reflections on Participatory Design: Lessons from the Trillium Experience. *CHI '90* (1990).
7. Dirk Brounen, Nils Kok, and John Quigley. 2012. *Residential energy use and conservation: Economics and demographics.* Technical Report. Goldman School of Public Policy.
8. Hrönn Brynjarsdóttir, Maria Håkansson, James Pierce, Eric P S Baumer, Carl Disalvo, and Phoebe Sengers. 2012. Sustainably Unpersuaded: How Persuasion Narrows Our Vision of Sustainability. *CHI '12* (2012).
9. Enrico Costanza, Sarvapali D. Ramchurn, and Nicholas R. Jennings. 2012. Understanding Domestic Energy Consumption Through Interactive Visualisation: A Field Study *(UbiComp '12)*. ACM, New York, NY, USA, 216–225.
10. Paul Dourish. 2010. HCI and environmental sustainability: the politics of design and the design of politics. *Proceedings of the 8th ACM Conference on Designing . . .* (2010), 1–10.
11. K Ehrhardt-Martinez, KA Donnelly, and S Laitner. 2010. *Advanced metering initiatives and residential feedback programs: a meta-review for household electricity-saving opportunities*. Technical Report. AEEE, Washington, DC.
12. U.S. Energy Information Administration (EIA). 2009. Residential Energy Consumption Survey (RECS). http://www.eia.gov/consumption/residential/. (2009). Accessed: 2016-02-02.
13. Corinna Fischer. 2008. Feedback on household electricity consumption: a tool for saving energy? *Energy Efficiency* 1 (2008).
14. Geraldine Fitzpatrick and Greg Smith. 2009. Technology-Enabled Feedback on Domestic Energy Consumption: Articulating a Set of Design Concerns. *IEEE Pervasive Computing* 8 (2009).
15. D. Foster, S. Lawson, C. Lineham, J. Wardman, and M. Blythe. 2012. 'Watts in it for me?' Design Implications for Implementing Effective Energy Interventions in Organisations. *Proc CHI '12* (2012).
16. Jonathan Grudin and John Pruitt. 2002. Personas, Participatory Design and Product Development: An Infrastructure for Engagement. In *Proceedings of Participation and Design Conference (PDC2002), Sweden*. 144–161.

17. Charlotte B.A. Kobus, Ruth Mugge, and Jan P.L. Schoormans. 2013. Washing when the sun is shining! How users interact with a household energy management system. *Ergonomics* 56, 3 (2013).

18. Timothy M. Miller, Patrick Rich, and Janet Davis. 2009. ADAPT: Audience Design of Ambient Persuasive Technology. *Proc CHI EA '09* (2009).

19. Michael J. Muller. 2002. Participatory Design: The Third Space in HCI. In *Handbook of Human-Computer Interaction*, Julie Jacko and Andrew Sears (Eds.). Lawrence Erlbaum Associates, Hillsdale, NJ.

20. Lene Nielsen. 2012. Acting as Someone Like Me ? personas in participatory innovation. In *Proceedings of the PIN-C 2012*.

21. M. (Michael) Short, M. (Muneeb) Dawood, T. (Tracey) Crosbie, and N. (Nashwan) Dawood. 2014. Visualization tools for energy awareness and management in energy positive neighborhoods. In *14th International Conference on Construction Applications of Virtual Reality*.

22. P. Shrubsole, T. Lavrysen, M. Janse, and H. Weda. 2011. Flo: Raising Family Awareness About Electricity Use. *Proc CHI EA '11* (2011).

23. Stephen Snow, Dhaval Vyas, and Margot Brereton. 2015. When an eco-feedback system joins the family. *Personal and Ubiquitous Computing* 19, 5 (2015).

24. A. Spagnolli, N. Corradi, L. Gamberini, E. Hoggan, G. Jacucci, C. Katzeff, L. Broms, and L. Jonsson. 2011. Eco-Feedback on the Go: Motivating Energy Awareness. *Computer* 44, 5 (May 2011).

25. Y. Strengers. 2011a. Negotiating everyday life: The role of energy and water consumption feedback. *Journal of Consumer Culture* 11, 3 (Dec. 2011).

26. Yolande Strengers. 2014. Smart Energy in Everyday Life: Are You Designing for Resource Man? *interactions* 21, 4 (July 2014).

27. Yolande A.A. Strengers. 2011b. Designing Eco-feedback Systems for Everyday Life *(CHI '11)*. ACM, New York, NY, USA, 2135–2144.

28. V. Sundramoorthy, Qi Liu, G. Cooper, N. Linge, and J. Cooper. 2010. DEHEMS: A user-driven domestic energy monitoring system. In *Internet of Things (IOT), 2010*.

29. Fenne van Doorn, Pieter Jan Stappers, and Mathieu Gielen. 2013. Design Research by Proxy: Using Children As Researchers to Gain Contextual Knowledge About User Experience. *(CHI '13)*. ACM, New York, NY, USA, 10.

30. Desley Vine, Laurie Buys, and Peter Morris. 2013. The Effectiveness of Energy Feedback for Conservation and Peak Demand: A Literature Review. In *Open Journal of Energy Efficiency*, Vol. 2.