

Energy Aware Campus Dwelling: Eco-Visualization and the IU Energy Challenge

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1. ABSTRACT

This report is focused on new design directions for the Energy Challenge 09, a student competition to conserve water and electricity in dormitories at the Indiana University Bloomington campus. These new design directions emphasize the use of eco-visualizations (EVs). EVs are *"any kind of interactive device targeted at revealing energy use in order to promote more sustainable behaviors or foster positive attitudes towards sustainable practices"* [Pierce et. al, (2008, forthcoming)].

This report presents (i) EV design strategies resulting from a critical survey of the emerging field of eco-visualization, (ii) results from contextual interviews with dorm students and evaluations of the Energy Challenge 08, (iii) design concepts for the Energy Challenge 09, and (iv) strategic considerations for the implementation of the Energy Challenge 09.

2. INTRODUCTION

Buildings consume considerable amounts of energy and water, and occupants typically have a high degree of control over their own personal consumption. For example, as originally quoted in [Peterson et. al, (2007), p. 17], *"Residential and commercial buildings account for two-thirds of the electricity used in the US, 36 percent of US greenhouse gasses, 9 percent of world greenhouse emissions, and 12 percent of US fresh water consumption [Wilson et. al, (2001)]. Previous studies have estimated that occupant activities and choices control up to 50 percent of residential energy use, while the balance depends on physical characteristics of buildings and building equipment over which occupants have no control [Schipper, (1989)]. Production of electrical energy contributes to a broad range of environmental and health problems including climate change, acid deposition, lung ailments, and mercury poisoning. Freshwater consumption (one source of energy use) leads to groundwater and surface water depletion, pollution, and habitat destruction."*

This consumption is typically hidden to building dwellers. This is particularly true for students living in campus housing. These students do not receive monthly utilities bills and have no direct financial incentives to limit their consumption of water and electricity.

This report presents continuing work related to promoting environmental sustainability and resource conservation amongst college students living in campus housing. In particular, this work emphasizes eco-visualizations (EVs), which *"are any kind of interactive device targeted at revealing energy use in order to promote more sustainable behaviors or foster positive attitudes towards sustainable practices"* [Pierce et. al, (2008, forthcoming)]. Eco-visualizations shift the focus away from *behind-the-scenes* engineering solutions towards the design of graphics, interfaces and systems aimed at actively promoting more sustainable interactions with respect to resource consumption. EVs typically bring issues of sustainability and resource consumption to the attention of the people engaging with the product, service or system employing the visualization. As we will see in the next section, EVs often bring these issues to bear in subtle, provocative and creative ways.

This report is concerned primarily with EVs in the context of a formal student competition to conserve water and electricity in student dormitories. From March 20 to April 17, 2008, students in 10 dormitories on the Indiana University Bloomington (IUB) campus competed in the Energy Challenge 08, a competition to save water and electricity. The primary goal of this report is to outline new design directions for the Energy Challenge 09.

This report presents (i) EV design strategies resulting from a critical survey of the emerging field of eco-visualization, (ii) results from contextual interviews with dorm students and an evaluation of the Energy Challenge 09, (iii) design concepts for the Energy Challenge 09, and (iv) strategic considerations for the implementation of the Energy Challenge 09.

3. BACKGROUND

3.1 The IU Energy Challenge 08

The Energy Challenge 08 took place from March 20 to April 17, 2008. Students in 10 dormitories on the IUB campus competed in the competition to save water and electricity. The winning dorms received cash prizes and celebratory cookout events. The competition resulted in an estimated combined savings of 33,008 KWh of electricity

and 724,322 gallons of water compared to baseline consumption of the previous three years.

The four main components of the Energy Challenge 08 design were (i) a competition website, (ii) a utilities information database, (iii) an online social-networking group, and (iv) promotional media.

Competition website. The primary mode of feedback for the competition was a website designed and implemented by David Roedl, who at the time of competition was a Masters student in the Human-Computer Interaction/Design program in the School of Informatics at Indiana University. The website (<http://energychallenge.indiana.edu>) provided an interactive visualization of the competition standings, displaying the rankings of each dormitory building and the amount of water and electricity as a percentage of a 1-month baseline, determined from average usage of the previous three months of April. The site also provided the official competition rules and a set of energy conservation tips.

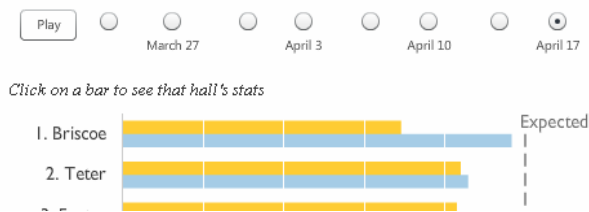


Figure 1. The Energy Challenge 08 competition standings interface.

Utilities database. The backend of the competition standings visualization consisted of a custom online SQL server database. This database was designed and implemented by Jeff Huang of the Utility Information Group at Indiana University. Meter readings were taken twice per week for electricity and water. Glenn Moulton, also of the Utilities Information Group, volunteered to take the biweekly readings during the duration of the competition.

Facebook group. An online social-networking group was created for the competition on Facebook.com. The group membership peaked at approximately 150 members during the competition.

Promotional media. Posters advertising the competition were designed by Kelly Breeze. These were displayed in each of the participating dorm during the competition. David Fuente of the Indiana Sustainability Task Force was also responsible for logistic and public relations work involved in the competition. A mass email was sent to every student living in the participating dorms during the first week of the competition.

3.2 Eco-Visualization

Recent work at the intersections of Human-Computer Interaction (HCI), design, information visualization and sustainability has led to the emerging field of *eco-visualization*. The term eco-visualization (EV) is used to

"devices aimed at revealing energy use in order to promote sustainable behaviors or foster positive attitudes towards sustainable practices" [Pierce et. al, (2008, forthcoming)]. Artist Tiffany Holmes first introduced the term *eco-visualization* to denote novel approaches to displaying *"the real time consumption statistics of key environmental resources for the goal of promoting ecological literacy"* [Holmes, (2007), p. 154]. Many diverse EVs currently exist. In the next section, strategies are drawn from a critical survey of EV in order to inform general EV research and design in future. These strategies are later applied to new conceptual direction for the Energy Challenge 09.

4. ECO-VISUALIZATION: A CRITICAL SURVEY

Note that the following section, slightly modified, has been included for publication in [Pierce et. al, (2008, forthcoming)].

In this section, a set of strategies for designing eco visualizations (EVs) is presented. EVs are *"any kind of interactive device targeted at revealing energy use in order to promote more sustainable behaviors or foster positive attitudes towards sustainable practices"* [Pierce et. al, (2008, forthcoming)]. The strategies presented have emerged from my own critical analysis and reflections on numerous diverse EVs. Through a set of carefully selected exemplars, a range of strategies currently being employed in the design of EVs are highlighted, suggesting both the breadth of this emerging field and directions for the design and evaluation of future EVs. These strategies include

- (i) offering behavioral cues and indicators,
- (ii) providing tools for analysis,
- (iii) creating social incentive to conserve,
- (iv) connecting behavior to material impacts of consumption,
- (v) encouraging playful engagement and exploration with energy,
- (vi) projecting and cultivating sustainable lifestyles and values,
- (vii) raising public awareness and facilitating discussion, and
- (viii) stimulating critical reflection.

The first two strategies relate to supporting conservation goals by providing clear and useful information or feedback. These visualizations tend to assume that the user already has some motivation to conserve energy (e.g. to save money, or reduce environmental footprint). The third and fourth strategies are focused on creating incentives to conserve, especially in contexts where financial incentives are not present. The final four strategies are focused on more experiential aspects of making consumption visible,

ideally helping to create or support conservation goals in the process.

4.1 Offering behavioral cues and indicators

A common approach to motivating energy conservation is to provide contextual, real-time feedback in the form of simple cues or indicators at or near the point of consumption with the goal of guiding behavior. A number of commercial products are currently available for residential homes, providing real-time feedback on total household consumption via a numerical display, e.g. the Eco-Eye (figure 3). An alternative to direct numerical feedback is ambient feedback, which uses pre-attentively processed information such as brightness or color differences in lighting to communicate changes in consumption.



Figure 3. The Eco-Eye [Eco-Eye.com, (2008)] (left) provides direct feedback on household electrical consumption, while the Wattson [DIY Kyoto, (2008)] (right) additionally provides ambient feedback.

The Wattson is a home energy monitor that integrates both direct and ambient feedback, providing real-time feedback on total energy consumption within the home. Current household electricity consumption is displayed numerically (in watts or Euros) as well via ambient lighting. As described on the designers' website, "When there's a purple glow, you're using the average for your home. And when they're red, you're using more electricity than usual." [DIY Kyoto, (2008)] The ambient lighting can thus provide cues indicating that consumption is high and the dweller should turn off appliances. The numerical display provides further information that may help users determine which appliances are consuming the most energy and should be switched off. Studies have indicated that savings on the order of 10% can be achieved in the home with the use of these types of real-time portable energy displays [Dobson et. al, (1992), Mountain, (2008)].

4.2 Providing tools for analysis and insight

Some systems offer more in depth feedback, allowing users to more deeply explore their consumption patterns. One example is the Lucid Building Dashboard. These dashboards are custom designed and built to be displayed on interactive kiosks in commercial or residential buildings.



Figure 2. Lucid Building Dashboard (left) [Brun, (2008)] and Holmes [DIY Kyoto, (2008)] (right) allow dwellers to explore in detail the patterns of consumption within their home or building.

The displays offer a variety of ways to explore in detail the consumption patterns of an entire building. A similar visualization tool called Holmes (figure 4) is designed specifically for residential use in conjunction with the Wattson. Holmes allows users to view energy use patterns over hours, days, weeks, or months, as well as set target reduction goals to work towards.

Uneo et al. [Uneo et. al, (2006)] tested an "on-line interactive 'energy-consumption information system' that displays power consumptions of, at most, 18 different appliances, power and city-gas consumption of the whole house and room temperature, for the purpose of motivating energy-saving activities" in 10 residential homes, resulting in 9% reduction in power consumption. However, there is still the issue of incentive—for many, financial or environmental incentives may not be enough to motivate one to conserve or to adopt such a tool in the first place.

4.3 Creating social incentive to conserve

One strategy used to encourage conservation goals is to combine EV with social incentives to conserve, such as in the context of formalized competition to reduce consumption. A study conducted at Oberlin College investigated the use of real-time data visualization provided to students during a "dorm energy competition." The competition resulted in an estimated 32 percent reduction in electricity use [Peterson et. al, (2007)]. Others have explored combining EV with individual conservation pledges in order to encourage conservation behavior. Tiffany Holmes' *7000 Oaks and Counting* (figure 6) is a public art project which "consists of a lobby-sited kiosk and website that display an animation of dynamic energy loads at the National Center for Supercomputing Applications (NCSA) in Urbana, IL." [Holmes, (2007), p. 153] The website component "invites building residents to make individual public commitments to reduce their own carbon footprint. After filling out a web form, the individual's name is incorporated into the animation sequence and the carbon offset is applied immediately to the building's total." [16, p. 160] Holmes notes that this commitment is based on trust, since there is no way to guarantee that users keep their pledge. However, as originally cited by Holmes, studies have demonstrated that making a commitment to conserve can lead to increased reduction in electricity consumption amongst those who pledge [Holmes, (2007), Katzev et. al, (1984)]. While higher-granularity data may offer the opportunity to provide more meaningful feedback to

individuals about their consumption, this project confronts such limitations by soliciting and visualizing individual pledges to conserve.

4.4. Connecting to material impacts of consumption

Often, it is difficult to connect individual actions (e.g. shutting off the lights) with the negative consequences of our collective actions (e.g. global warming). Many EVs communicate electricity consumed in terms of environmental figures such as pounds of CO₂ emitted or number of trees required to offset these CO₂ emissions.

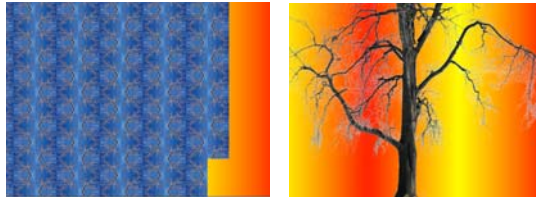


Figure 4. Animation stills from Tiffany Holmes' *7000 Oaks and Counting* project, representing high loads (left) and low loads (right).

As an alternative to statistical figures, some have experimented with using visual metaphors to forge a connection between consumption and environmental impacts. The *7000 Oaks and Counting* project (figure 6) uses an animation of a series of tree images to show the number of trees needed to offset the energy consumed by the building: "One of the key issues in visualizing energy consumption data is the sheer scale of the numbers. Trees are considerably easier to picture as opposed to...kilowatt hours. The animation brings a little of the outdoors inside: most individuals maintain positive feelings toward trees, particularly species familiar to them." [Holmes, (2007), p. 160]

The visualization attempts to communicate numerical statistics in a more meaningful way, creating an emotional connection between the individual and the environmental consequences of electricity consumption. Holmes explicitly acknowledges the deliberate decision to use natural and aesthetic imagery in her visualization as a means to provoke an aesthetic experience in the user.

4.5 Encouraging playful engagement and exploration with energy

The importance of designing for *ludic activities* or "activities motivated by curiosity, exploration, and reflection rather than externally defined tasks" has recently been brought to attention within HCI [Gaver, (2004), p. 885]. In the context of energy visualization, the Static! group at the Interactive Institute has developed a research program aimed at developing "a more profound understanding of energy as material in design, including its expressive and aesthetic potential." [Backlund et. al, (2006), p. 1] One example of this group's work is the previously discussed Power-Aware Cord (figure 1), designed to "make the user, to some extent, perceive the

light as the actual electricity." [Backlund et. al, p. 12] While this device does provide behavioral cues—such as indicating devices which are plugged in and consuming energy yet not being used, hence should be unplugged—it is noteworthy in the way it explores the aesthetic potential of energy as a design material. The Power-Aware Cord is not simply visualizing information; it is also encouraging users to engage physically with energy. This engagement may be for the sole pleasure of engaging with energy as a visible and tangible thing, rather than with some conservation or educational purpose. Nonetheless, increased awareness and incentive to conserve may emerge through such playful engagement with the Power-Aware Cord and electrical devices.

4.6 Projecting and cultivating sustainable lifestyles and values

Many of the visualizations already discussed serve both symbolic and practical functions. For example, the Lucid Building dashboard may provide information that motivates or informs conservation behavior, but it also communicates that the building owners, managers, or dwellers care about energy conservation. Indeed, a building dashboard is an important way in which buildings that purport to be "green" can show visitors and building dwellers how efficient they are, perhaps even highlighting energy efficient technology that may be less visible, such as solar panels or efficient heating and cooling systems.



Figure 5. Vision Energy Sculpture [Information Aesthetics, (2008)] (left) dynamically represents energy consumption levels. The Energy Curtain [35] (right) collects sunlight on its exterior during the day and displays it as glowing patterns on the interior of curtain at night.

An example of a design serving a more purely symbolic function is the Vision Energy Sculpture, a concept for dynamic sculpture which reflects the energy consumption levels in a home or building: "By means of a three step scale symbolizing either no economization, justifiable average consumption or the achievement of the benchmark value, the subject of energy comes visually alive and at the same time encourages society to be more conscious regarding the usage of resources." [BraunPrize 2007, (2008)]

The aesthetic form is something the owner would be proud to display, serving as a symbol of sustainable values and lifestyle to others. The dynamic form of the sculpture can serve as a symbol of a personal commitment to conservation. While it may not be particularly useful in informing specific behaviors through detailed feedback, it can function as a persistent reminder to reduce consumption, possibly extending to behaviors outside the immediate use-context.

4.7 Facilitating discussion and raising public awareness

Some EVs are focused primarily on bringing issues of energy conservation to the forefront of public awareness and discussion. A prime example is the *Nuage Vert* (described briefly above), an art installation in Helsinki where the energy consumption of the entire city was visualized in the form of a cloud projected with lasers onto the smoke emitted from the city's coal-burning power plant (figure 1). Every night from the 22 to the 29 of February 2008, the emissions were illuminated with the green cloud; the lower the consumption, the larger the illumination projected. An "unplug event" was held on the last day of the installation in which residents were asked to unplug devices to reduce consumption, increasing the size of the "green cloud" projected into the sky. The event succeeded in reducing maximum demand by 800 kVA during the one hour period it was held [Nuage Vert, (2008)].

The Nuage Vert project demonstrates the potential for EV to bring issues of energy consumption and environmental sustainability to the forefront, and prompt social action. The project also illustrated that aggregated, small granularity data can be effective in persuading people to conserve.

4.8 Stimulating critical reflection

Recent work in HCI and design has advocated critical approaches to the design of technology which encourages reflection on technology itself, the way it conditions behavior and the ideological assumptions embedded in it [Dunne et. al, (2001), Sengers et. al, (2005)]. One exemplar of a critical approach to EV is the Energy Curtain (figure 6) "...a window shade woven from a combination of textile, solar-collection and light-emitting materials... During the day, the shade can be drawn to the extent that people choose to collect sunlight and, during the evening, the collected energy is expressed as a glowing pattern on the inside of the shade." [Static!, (2008)]

However, using the Energy Curtain can actually encourage unsustainable behaviors. I have elsewhere reported that "Closing the curtain during the day will cause the room to darken, possibly requiring the use of artificial lighting. The energy curtain thus forces the user to decide between either using natural light and not being rewarded with the glowing pattern, or using artificial light and being rewarded." [Pierce & Roedl, (2008), p. 7].

Through use, the Energy Curtain can "provoke the realization of how design...renders energy abstract and intangible, and hides the energy costs of our actions" [Pierce & Roedl, (2008), p. 7]. The Energy Curtain may actually encourage energy consumption locally for the purpose of stimulating reflection on how technology itself can encourage consumption.

Critical approaches to EV design can also lead to more pragmatic behavioral and intellectual changes. For example, artist Natalie Jeremijenko has proposed a power meter that is "accurate, high-tech, and digital, yet as dumb as a brick"

[Jeremijenko, (2001)]. Unlike conventional approaches to power meters aimed at encouraging energy conservation in the home, this meter forces users to estimate how much energy is being consumed before it will display the actual usage: "Let's say you are consuming ten kilowatts. If you say 'Nine' or 'Eleven,' the meter will stay impassively blank. But if you say 'Ten,' the exact electricity consumption will then display. The meter will show you your exact current consumption rate at that moment: say, 10,768 watts" [Jeremijenko, (2001)].

Ideally, this "dumb" energy meter would both train the user to recognize the patterns of his or her energy consumption and cause a realization that technology is not perfect and responsibility must be taken over an individual's own consumption behavior. "Because people are good at learning, this device ultimately makes itself obsolete" and can be passed on to a friend or neighbor [Jeremijenko, (2001)].

5. DESIGN RESEARCH AND EVALUATION OF ENERGY CHALLENGE 08

5.1 Methods

5.1.1 Contextual interviews

In order to determine opportunities and barriers to the design of the Energy Challenge, as well as gain a better understanding of the lives of college students, contextual interviews were conducted with six students living in the IU dormitories. These interviews were conducted with help of Will Odom, a Human-Computer Interaction / Design researcher and Masters student in the Department of Informatics at Indiana University. Interviews were conducted during the first week of competition between March 20 and March 27, 2008. Originally, we had plans to evaluate student participation in the competition. However, none of the participants we interviewed were aware of the competition before our interviews. This was likely due in part to the fact that the competition had not yet been advertised with posters and mass-email.

Three of the participants were recruited from Collins, a dormitory with a reputation for a student population sympathetic to environmental and social issues. Although Collins was unable to participate in the Energy Challenge due to a problem with the building's utility metering, we wanted to learn more about a student group that had strong potential to seriously engage in the Energy Challenge and energy conservation. The remaining three participants were recruited from Foster, a dormitory with a population more representative of the general undergraduate population at Indiana University.

Student participants guided researchers on a tour of their dorm rooms, answering questions related to their use of energy consuming products, feelings and relationships towards energy consumption, and motivations to participate in the competition and conservation.

5.1.2 Follow-up student survey and competition website traffic analysis.

In order to evaluate student participation in the Energy Challenge 08, an online survey was designed and administered by David Roedl. A total of 49 students participated in the survey. Survey participants were recruited through the competition's Facebook social networking group, which accumulated approximately 150 members over the course of the competition. This skewed the sample towards students who were engaged in the competition and motivated to conserve. Analytics from the competition website designed by Roedl were also reviewed.

5.2 Results

Despite a small sample size, our qualitative data painted a rich portrait of dorm life and the behaviors and motivations of college students with respect to resource consumption. Quantitative data from the online survey and website analytics complemented insights from our qualitative data. Insights have been organized into four areas: *awareness and engagements, motivation, knowledge, and empowerment.*

5.2.1 Awareness and engagement

41.5% of survey participants reported that they never checked the online competition standings. 43.9% checked the standings 1-2 times and 14.6% checked 3-5 times. Competition website analytics report 2,290 page visits and 4,992 page views. 75% of the visits were new visits. 1,719 people visited the site. At the time of the competition, there were approximately 10,000 students living in the competing dorm buildings.

These findings indicate that students were not very engaged in the competition itself since they did not frequently check on their buildings progress in the competition. An obvious improvement to the competition design would be to display the competition standings in public spaces, rather than requiring students to look online on their own personal computers to view the standings.

5.2.2 Motivation

While a few students voiced concern over environmental issues and resource consumption, participants appeared to be largely unmotivated to change their behavior based solely on environmental consequences. Our observations suggest that student consumption behaviors are strongly influenced by their peers. For example, one participant said *"When I came to college, people commented on my waste of water and leaving lights on, and so I started to become more conscious of it."* Social motivation surfaced as a component essential to the competition's success. The same participant also stated that *"...if all the girls on my floor really wanted to win, I'd try to save energy; otherwise, I probably wouldn't do anything differently."*

However, the follow-up surveys and website analytics suggest that social motivation to participate was not very strong amongst students. In response to the survey question

"What issues, if any, prevented you from participating more fully in the Energy Challenge?", 44.2% of respondents selected "No one else was competing so there didn't seem to be a point."

5.2.3 Knowledge

Interview and survey data both indicate that students are generally unaware of concrete steps they can take to reduce their own consumption, beyond the most basic actions. During contextual interviews, students were asked what actions they personally could take to reduce consumption if they wanted to win the competition. Every student interviewed noted turning off lights as a first step they would take. However, most students had difficulty offering additional conservation actions. One student remarked *"there's not really anything you can do besides turning off lights."*

Oftentimes, residents did not believe they were using much energy. The most common conservation actions cited by students (e.g. not letting water run or turning off lights when exiting room) were often attributed by students to practices engrained in them by their parents. In response to the survey question *"during the competition, which strategies, if any, did you use to reduce energy or water use?", 93.5% selected "keeping room lights off when it is unoccupied" while only 21.7% selected "turning off power strips or unplugging devices".* Not only was it widely unknown that unplugging devices that consume standby power could reduce consumption, but most residents found it difficult to conceptualize how much energy (in kilowatt hours) and water (in gallons) they— as well as their building and the entire campus—use on a daily or monthly basis. This finding suggests that concrete feedback is important to link less visible energy consuming devices (e.g. plugged in phone chargers) with a reduction in overall consumption.

Given that survey respondents were likely more environmentally conscious than the general student population, we might infer that the average student at IUB is even less knowledgeable about how to reduce personal resource consumption.

5.2.4 Empowerment

Findings also suggest that the competition did not fully empower potential student leaders to reduce their own personal consumption and encourage others to, as well. Students interviewed at the Collins dorm were generally more knowledgeable and interested in issues related to environmental sustainability and resource conservation. One student we interviewed proved quite knowledgeable and motivated to participate, remarking that *"I'd do whatever it takes to win this competition!"* Unfortunately, students living in Collins could not participate in the competition due to technical problems with the building's utility metering.

As noted earlier, the 49 survey respondents were recruited from the competition Facebook group consisting of approximately 150 members, suggesting the respondents were more motivated by the competition or conservation than the general student population. However, as discussed earlier, these students appeared to be lacking in their levels of engagement in the competition, motivation to participate and knowledge of how to effectively participate. This suggests that in the future, the competition should aim to empower potential student leaders-- particularly the students already motivated by issues of environmental sustainability-- to engage in extreme forms of participation, encouraging others to follow in their footsteps.

6. DESIGN CONCEPTS

A range of design concepts was explored, informed by insights resulting from (i) a critical survey of the emerging field of eco-visualization, (ii) contextual interviews with students living in the IUB dormitories, and (iii) an evaluation of the Energy Challenge 08. Six of these concepts are presented here:

- Consumption Kiosks
- The Energy-Aware Lounge
- Student Pledge-Form
- Student Pledge-Wall
- Post-It Conservation Reminders
- The Consumption Scavenger Hunt

These six concepts have been organized according to the areas of *general awareness and engagement*, *acknowledgment and accountability*, and *individual-level tools and challenges*.

6.1 General Awareness and Engagement

The following concepts are designed with the primary goal of advertising the Energy Challenge competition and attracting students to participate in energy conservation. These concepts are targeted at a general student population, particularly students without strong intrinsic motivation to participate in the competition or reduce their own resource consumption. Design strategies of particular relevance to these goals include: *encouraging playful engagement and exploration with energy*, *projecting and cultivating sustainable lifestyles and values*, *raising public awareness and facilitating discussion*, and *stimulating critical reflection*.

6.1.2 Consumption Kiosks

Consumption Kiosks are interactive touch-screen computer displays intended for high traffic public spaces, such as the lobby of student dormitories. The kiosks have two primary purposes. First, these kiosks provide useful or interesting information related to the resource consumption. Second, consumption kiosks are intended to advertise the

competition and remind students that the competition is in progress. Furthermore, these kiosks send a message to students and visitors that energy conservation is an important part of dormitory life.

6.1.2 The Energy-Aware Lounge

The Energy-Aware Lounge is a hybrid of an interactive museum exhibit and public dorm lounge or dorm room. Although students can use The Energy-Aware Lounge to learn about energy consumption and the amount of energy consumed by individual appliances, the primary goal of the lounge is to advertise the competition and encourage students to engage with energy in fun and interesting ways. As with Consumption Kiosks, The Energy-Aware Lounge is intended to be set up in high-traffic public spaces in, such as dorm lobbies, reading rooms, or cafeterias. The lounge contains a variety of furniture for students to sit on, as well as energy consuming products such as televisions, microwaves, computers, lamps, and compact refrigerators. The amount of energy consumed by the products is visualized using one of several types of visualization. One option is to use a commercial product such as the Wattson [DIY Kyoto, (2008)] or Powercost Monitor [Powercost, (2008)] which display the amount of energy being consumed collectively by all of the products in the lounge. Alternatively, a device-level monitor could be constructed displaying the disaggregated usage of individual products. The hardware plans for such monitors has been developed by Jeffrey Leblanc and are available online [Leblanc, (2008)]. Alternative designs could also be explored, such as an augmented reality display (figure 6) which visualizes the energy consumed by appliances as glowing lights around the appliance. Installations using any of the visualization discussed could also allow students to plug in their own devices to see how much energy they consume.

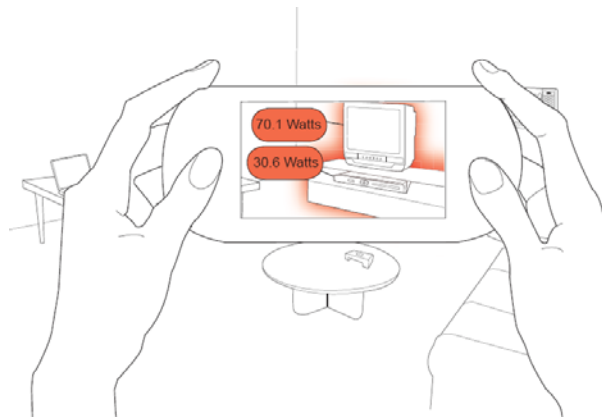


Figure 6. The Energy-Aware Lounge promotes the Energy Challenge 09 and encourages students to playfully engage with energy.

6.2 Acknowledgment and Accountability

The next set of concepts are designed with the primary goal of encouraging students to participate in the competition on a regular basis by taking concrete steps to reduce their own consumption and by actively promoting the competition to

others. Design strategies of particular relevance to these goals include *creating social incentive to conserve*, and *connecting behavior to material impacts of consumption*.

6.2.1 Student Pledge-Form

The student Pledge-Form is a web application which allows students to pledge specific conservation actions (e.g. turn of the lights when not in use this month) and calculate the estimated savings associated with each pledge action. The Pledge-Form is divided into six sections: "progress", "turn-off", "adjust", "unplug", "comment", and "pledge". Brief descriptions of each section are presented in turn.

Progress. The first section of the form allows students to view how to see how much their dorm has reduced or increased water and energy consumption thus far this month. Students can also view the number of pledges made and corresponding reductions in electricity and water consumption estimated.

Turn-Off, Adjust, and Unplug. Students can select from a predefined set of conservation actions organized according to the themes of "turn-off" "adjust" and unplug". For example, a student can pledge to "do one less load of laundry this month", "replace one incandescent light bulb with a compact fluorescent (CFL)", and "unplug desktop computer and monitor when not in use this month". Selecting each of these actions displays an estimated savings of 12.5 kilowatt hours (kWh) and 50 gallons (gal) of water.

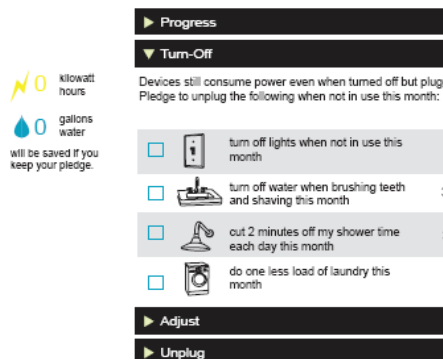


Figure 7. The student Pledge-Form allows students to pledge specific conservation actions and calculate the estimated savings associated with each pledge action

Comment. In this section, students can make an open-ended pledge or comment. Recent pledges from other students are displayed, with the option to view all pledges made thus far.

Pledge. Finally, students have the option to submit their pledge. Students may also choose to receive email reminders to keep their pledge and also have the option to have their pledge displayed publicly. The mechanism for public display is the *Pledge-Wall*, discussed next.

6.2.2 Student Pledge-Wall

The *Student Pledge-Wall* is implemented using the Consumption Kiosks discussed in the previous section. One kiosk displays the pledge form discussed above. Another kiosk displays the pledges made by students. After a student submits a pledge-- opting to make the pledge public-- the student's name is added to the pledge wall. Holding the mouse cursor over a name displays the student's pledge, including any comment they made. The pledge wall also displays the information from the "progress" section of the pledge form, indicating whether the dormitory has collectively reduced or increased resource consumption at this stage in the competition, and comparing these figures to estimated pledges made by students.

By publicly displaying student pledges in the lobby of each dormitory building, students are encouraged to pledge conservation actions and participate in the competition. Public pledges also serve as a persistent reminder to students to keep their pledges.

6.3 Individual-Level Tools and Challenges

The final set of design concepts is focused on encouraging and supporting students who may want to engage more deeply with energy conservation in terms of learning about conservation, participating in the competition or actively promoting the competition to others. The design strategies of *offering behavioral cues and indicators* and *providing tools for analysis* are of particular relevance.

6.3.1 Post-It Conservation Reminders

Post-It Conservation Reminders are a set of simple infographics aimed at providing students with contextual reminders to conserve water and electricity, while also providing more detailed information about the consumption resulting from everyday behaviors. Post-It Conservation Reminders consists of a set of almost 40 conservation reminders. Each reminder consists of a resource conserving action, an estimated savings resulting from the action, and a more detailed calculation of how the estimation was derived (figure 8).

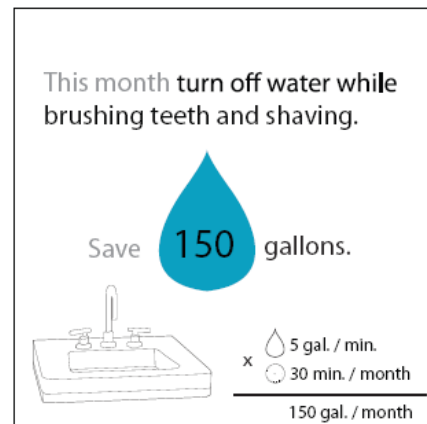


Figure 8. Post-It Conservation Reminders contain a resource conserving action, an estimated savings and a calculation of this savings.

Post-It Conservation Reminders are printed on adhesive paper, encouraging students and staff to display the reminders. For example, resident assistants (RAs) can use the reminders to decorate bulletin boards on dormitory floors. Students can remove the reminders and place them in relevant locations. Blank notes encourage students to create their own reminders or other thoughts and comments concerning resource conservation and the Energy Challenge. Post-It Conservation Reminders thus aim to empower student leaders of the competition, as well as provide useful contextual reminders to conserve.

6.3.2 Consumption Scavenger Hunt

The *Consumption Scavenger Hunt* is a competitive activity designed to encourage students to playfully engage with learning about energy consumption. Groups of participating students compete in a set of challenges related to energy consumption. Each participating group is presented with a set of *challenge cards* and an *energy capture tool*—such as the commercially available Kill-A-Watt [P3 International, (2008)]—a device which measures the electricity consumed by an individual appliance. Using the energy capture tool and digital camera, students document the completion of individual challenges, such as "find a TV which consumes less than 50 Watts when turned on." (figure 9) Points are awarded for the successful completion of challenges at the end of the activity in order to determine the winning teams.

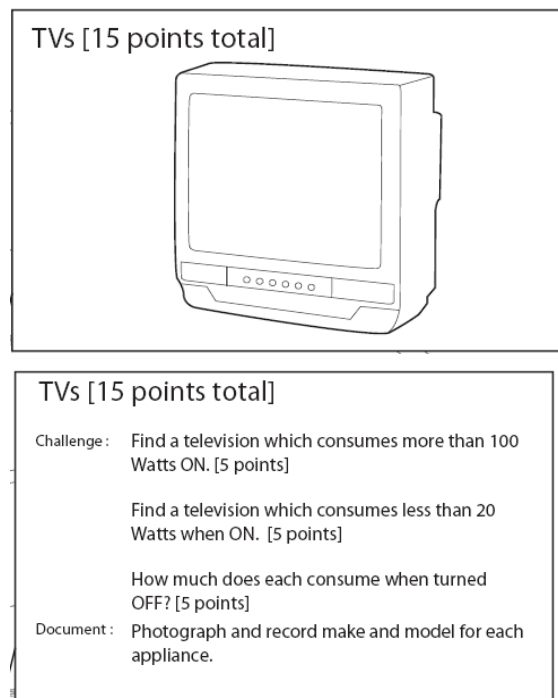


Figure 9. Student participating in the Energy Scavenger Hunt are presented with a set of challenges related to energy consumption.

7. IMPLEMENTATION STRATEGIES

In this section, strategic issues related to the implementation of the Energy Challenge 09 are discussed. These have been organized into three areas, namely (i) publicity and promotion, (ii) competition structure, (iii) incentives.

7.1 Publicity and promotion

A major insight from contextual interviews and the competition evaluation was that the competition needs to have a stronger presence in order attract and engage students. Consumption Kiosks and The Energy-Aware Lounge are aimed at creating physical and contextual reminders of the competition. Such concepts are essential in actively promoting the competition and encouraging students to participate.

High traffic areas suitable for installations such as Consumption Kiosks or The Energy Aware Lounge should be identified in each dormitory building. Additionally, areas in public buildings on campus, such as the library or student Union, may also be considered.

7.2 Competition structure

Analysis of the Energy Challenge 08 also revealed potential problems in the structure of the competition. Students in buildings trailing far behind in the competition may have little incentive to continue competing. This suggests that prizes should be awarded to every building that reduces consumption compared to the baseline estimate. Prizes could still be awarded to the buildings which consume the least compared to other buildings.

Furthermore, research findings indicated that students often had trouble connecting their individual actions with the collective impacts of an entire building. This suggests the importance of individual-level challenges, such as the Consumption Scavenger Hunt. Other individual-level challenges could also be provided, such as entering student pledges into a raffle, or awarding prizes for the "most creative conservation act" submitting in the open-ended portion of the Pledge-Form.

To summarize, at least three levels of competition should be considered:

1. *Collective dorms.* All dormitories compete to reduce consumption, and whoever reduces the most wins.
2. *Individual dorms.* Individual dormitories compete against their own baseline figures. Dormitories which reduce consumption are awarded a prize.
3. *Individual students.* Individual students or groups of students compete in challenges related to conservation. Individual prizes are awarded to the students that win these challenges.

7.3 Incentives

A set of prizes should be awarded for each of the levels of competition described above. In order to establish the

Energy Challenge as a valued and important aspect of dorm life, a trophy or similar award should be designed to be presented to the building(s) which reduce consumption by the most. Partnerships with local businesses can be established to provide prizes for individual-level challenges.

8. CONCLUSIONS

This report has outlined recommendations for new design concepts for the Energy Challenge 09, as well as strategic considerations for its implementation. These recommendations have been informed by (i) EV design strategies resulting from a critical survey of the emerging field of eco-visualization, and (ii) results from contextual interviews with dorm students and evaluations of the Energy Challenge 08. During the Fall 2008 semester, several of these concepts will continue to be refined and implemented in time for the Energy Challenge 09.

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