# The Design of Persuasive System for Sustainability in the Workplace

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**Abstract.** Office workers typically care little about saving energy because they are not responsible for paying energy-related bills. The goal of this study is to find ways to reduce the unconscious negative impact by applying persuasive technologies to create awareness and encourage office workers towards more environmentally-sustainable behavior. This paper presents a summary of the intervention techniques, the persuasive system prototype, the preliminary findings from the pilot studies, and the plans for future studies.

## 1 Introduction

Office buildings consume 36% of electrical energy in the United States [1]. If office workers turn off their devices when not in use and set up the power management to the energy-saving mode, this can reduce 12-20% of electricity consumption [2]. HCI researchers argue that technology can motivate people to change their behavior in a sustainable way by presenting them in forms such as computer games [e.g., 3], ambient displays [e.g., 4], and mobile applications. [e.g., 5]. Whereas many related studies in the field of Persuasive technology, HCI, and environmental psychology have targeted households [6], few studies focus on the domain of the workplace. In this research I focus on office workers, because unlike domestic users, they are not typically responsible for paying for electricity and thus tend to care little about saving energy in their workplace [7].

## 2 Intervention Techniques

Yun et al. [15] reviewed intervention techniques that can be effectively employed in the domain of the workplace. Of nine suggested techniques, this study focuses on the following interventions: self-monitoring, advice, and control. Here is a brief summary of the intervention techniques.

**Self-monitoring**: This has been widely employed and studied in the field of persuasive technology [8]. It allows people to learn their performance (energy consumption), and explore where they could do better (save energy). Self-monitoring alone can contribute 7% towards electricity savings [9] and the savings may increase when the monitoring shows appliance-specific data [10] frequently and immediately [8], compared with historic data [10] or other people's data [16] in monetary units [7].

**Advice:** This suggests what people can do to achieve the goal (saving energy). The form of advice varies but can include emails, text messages, an agent's dialogue, or a mission in the game. Advice can reduce electricity consumption up to 14.4% [10] and personalized advice can promote pro-environmental behavior [11].

**Control**: This increases behavior cost (providing an easy way to control energy consumption) and motivates behavior change (to save energy). This is similar to Fogg's reduction principle [8] which says, "reducing complex behavior into simple tasks increases the cost/benefit ratio of the behavior and motivates users to perform it." Control intervention can save up to 55% of energy consumption [12], but it still has not been thoroughly investigated.

## 3 Prototype

I implemented the intervention techniques in the user interface (Fig. 1) targeting office workers who are proficient in using computers. To enable measuring a user's electricity consumption per electronic item and to allow the users to remotely control them, I used Plugwise [14]. Plugwise's individual meters send the user's consumption data wirelessly to the server in real time and receive control commands from the server when users try to actuate each device remotely. Using this data I designed and developed a PHP web application and implemented each intervention technique as follows.

**Self-monitoring:** To assist people to understand their energy consumption pattern, I designed our chart to display real-time data and historic data for individual (breakdown) devices [8,10]. I provide different display intervals (day, week, month, year) and chart types (bar, area, line) so that people can view their energy consumption in various perspectives. By clicking specific items in the legend section, users can hide/display them in the chart and by hovering over a data point, they can view the numeric values and related statistics. The chart also projects the past data, so that people can understand what their consumption was (e.g. a week ago or a month ago) and predict their performance.

**Advice:** I designed two types of recommendations: short-term and long-term. The short-term recommendation is to suggest what users can easily do immediately (e.g., turn off their lamp). The recommendations are generated based on the decision tree using each device's current status (active / idle / sleep / off), sensitivity (sensitive / non-sensitive / special). It suggests not only to turn off the specific item when not in use, but also to set up power management if it is a computer or a printer. A long-term recommendation suggests replacing an energy hog with an energy-efficient device such as an energy-star product so that it can eventually save energy over the long-term.

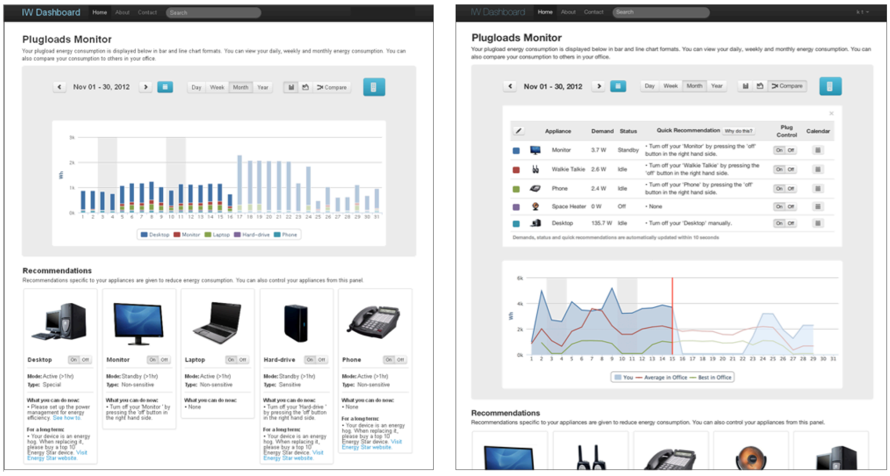


**Fig. 1.** Self-monitoring and recommendation (left), and control panel (right)

**Control:** In order for office workers to safely control their items with the web-based application, I first identified the sensitivity of typical devices they use in the workplace. For example, I categorized the following items as sensitive: 1) main desktop computers and monitors to access the dashboard, 2) servers, modems, routers to enable network connectivity, and 3) refrigerators that should be turned on all the time. All the rest are categorized as remotely controllable items (e.g., fan, lamp, or secondary monitor). The application allows users to control the items individually or as a group.

In addition to the web-based application, a public touch display for the shared appliances and a mobile application are currently being developed (Fig. 2). These will allow people to access the data information, control their devices more easily, and eventually provide a greater chance to save more energy.

# 4 Evaluation

## 4.1 Pilot study

With the first web-based application, an energy dashboard, I conducted a pilot study with twenty-two people at three sites (six people in a university lab, eight people in a university office, and eight people in a government research lab. No control group was formed in this pilot study due to the sample size of the groups.) [13] More than 120 appliances were monitored for eight weeks in this study. After one month into the study, I conducted an initial data analysis: Two of the sites showed significant energy savings (the university lab: 31.5%, the government research lab: -5%, the university office: 30%). To understand what contributed to this result and what didn't, I distributed questionnaires about the dashboard's learnability, usability and engagement to our users and twelve of them responded. Most of them think they received useful and clear information (11/12) and it influenced them to behave environmentally (9/12). Self-monitoring was appreciated the most (7/12) because they learned the most about their performance from it, and control intervention was the least popular because they are not yet used to controlling appliances via a user interface (2/12). The workers in the government lab had an internal policy to keep the lab computers on all the time, so our recommendations did not work well for one of their most power-consuming devices. The university office achieved 54% and 79% savings during the weekend and weekday nights respectively, and I predict that this energy savings could potentially reach 100% each.

**Fig. 2.** Prototype examples: a web-based application (left), public touch display for the shared appliances (middle) and mobile application (right)

### 4.2 Upcoming longitudinal study plan

Following the pilot study, I will explore the interventions in more depth. I will group self-monitoring and advice as one group and call it *feedback* interventions [16]. I will compare the *feedback* and *control* interventions by measuring three objectives: 1) energy conservation, 2) energy awareness, and 3) persistent energy savings after the system is removed. To investigate this, I will create four groups (twenty people per group) and collect each group's energy consumption data for one to two months as a baseline study. Before we provide interventions, we will conduct a survey to monitor their awareness about energy consumption. (These will be questionnaires about simple knowledge on energy consumption). Then, to each group respectively, we will provide no intervention, feedback only, control only, and both feedback and control for three to four months. We will measure an individual's energy consumption and investigate if there is any significant energy conservation after we provide the interventions. We will do a second survey to see if their awareness has improved. Then, we will remove the system for two to three months and see if persistent energy savings will occur even after the system is removed.

We have three hypotheses about the study outlined above. First, the dashboard system that provides feedback (self-monitoring and advice) will increase energy savings, energy awareness, and persistent energy savings with and without the system. Second, control without feedback (Self-monitoring and advice) will save less energy, and result in less energy awareness and less persistent energy savings than dashboards with feedback but without control. Third, the dashboard system that combines feedback (Self-monitoring and advice) and control will produce the greatest energy savings, energy awareness, and persistent energy savings.

## 5 Summary

In this paper I present the intervention techniques that I have focused on and demonstrate a persuasive system prototype, the preliminary findings from the pilot study, and the future study plan. A series of future studies described here will compare types of interventions to see which type is the most effective at saving energy in an office environment. I hope to suggest intervention techniques for the design of a system that promotes sustainability in the workplace.

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