Home Energy Consumption Feedback: A User Survey

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Abstract

Buildings account for a relevant fraction of the energy consumed by a country, up to 20-40% of the yearly energy consumption. If only electricity is considered, the fraction is even bigger, reaching around 73% of the total electricity consumption, equally divided into residential and commercial dwellings. Building and Home Automation have a potential to profoundly impact current and future buildings' energy efficiency by informing users about their current consumption patterns, by suggesting more efficient behaviors, and by pro-actively changing/modifying user actions for reducing the associated energy wastes. In this paper we investigate the capability of an automated home to automatically, and timely, inform users about energy consumption, by harvesting opinions of residential inhabitants on energy feedback interfaces. We report here the results of an on-line survey, involving nearly a thousand participants, about feedback mechanisms suggested by the research community, with the goal of understanding what feedback is felt by home inhabitants easier to understand, more likely to be used, and more effective in promoting behavior changes. Contextually, we also collect and distill users' attitude towards in-home energy displays and their preferred locations, gathering useful insights on user-driven design of more effective in-home energy displays.

Keywords: Energy, In-Home Display, IHD, Survey, User Interface

1. Introduction

In the last years, energy conservation and sustainable living gained ever increasing attention fostered by many factors including the political situation, economic stagnation, greener lifestyles and philosophies. Counterintuitively energy conservation, in developed countries, is currently more related to residential houses than to industry and commercial production. Homes, in fact, are becoming one of the major contributors to the countries energy balances, as demonstrated by statistics provided by the energy departments of USA and European Union. Typical forecasts for home energy consumption show ever increasing and worrying figures, that in the near future will probably exceed 40% of the total yearly consumption [1], in most of the western countries. This increased awareness fosters and motivates many research efforts on saving energy at home, ranging from making homes smarter and more energy friendly to increasing awareness of home

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inhabitants inducing important behavior changes in the daily routines of households. Householder awareness, in particular, has a saving potential of around 5%-15% [2], meaning that just by slightly changing their daily behaviors, home users can save up to 15% of their current energy needs. However, convincing people to change daily routines is not trivial and can seldom rely on almost static, monthly information written on paper bills or on-line energy accounts. Direct, real-time feedback is needed, instead, to constantly inform users about the energy efficiency of their customary behaviors.

In this paper we report the results of a web-based survey we carried during the initial phase of a IHD design, as part of a wider effort on applying user centered design methodologies to the whole design process of in-home displays, including their interactions with existing home automation systems.

The survey goal is to validate two different visualization and interaction modalities for increasing electric energy-consumption awareness (energy goal setting and direct power feedback) against the needs of a wide user base (992 users) of technology-aware[1] people living in a home. We designed two prototype interfaces respectively implementing direct visualization of currently absorbed electric power and goal-setting for the electric energy consumed in a day. We required users to watch and analyze 2 simple video mock-ups, and to respond to a set of carefully designed questions (Section 5), aiming at:

a) understanding whether people better comprehend and accept energy goal setting or direct power consumption visualizations;

b) verifying/confirming the willingness of surveyed users to actually adopt an in-home energy display;

c) checking if color-based feedback, i.e., feedback using color variations in parallel with explicit numbers[2], is effective in conveying information about energy/power consumption;

d) evaluating room-level repartition of goal and power data, verifying if corresponding visualizations are easy to understand by users, if such information is felt useful and if more (or less) detail is needed;

e) gathering the users' preferred setting and position for IHDs.

A total amount of 992 users participated in the survey, mostly from Italy with contributions from Spain, Finland and USA. Survey results provide interesting insights about the analyzed IHD visualizations.

The remainder of the paper is organized as follows: Section 2 reports related works and provides a quick overview on the state-of-the-art of in-home energy displays. Section 3 introduces the interaction and visualization paradigms that are currently attracting more consensus by the research community and Section 4 details how these paradigms have been considered in the design of the proposed visualizations. Section 5 describes the survey design and deployment while Section 6 reports the survey results referred to both visualizations. Section 7 discusses survey results and Section 8 concludes the paper and proposes future works. Finally, Appendix A reports full details of the survey results while additional video material is available on-line.

[1] We define technology-aware people as persons habitually using basic web technologies (browser and e-mail).

[2] which are required anyway, e.g., for enabling color-blind persons to use the IHD.

2. Related Works

Home energy consumption and related user behaviors are currently being studied by several research groups worldwide, with the aim of understanding how home inhabitants consume energy and with the goal of finding new interactions and habits in the home able to encourage more energy-efficient behaviors. In this context, research studies mainly involve: house occupant characterization [3], and behavior modeling [4, 5, 6, 7], mining and simulation of typical consumption profiles [8, 9], rule-based management systems for reducing consumptions of daily activities [10] and feedback interfaces and monitors able to "persuade" users to modify or adapt their habits to achieve increased savings [11, 12]. These various effects (user habits, automation,...) can be fruitfully combined in real settings, but we believe they are best analyzed separately.

As proven by many research pilots and surveys [3, 13, 14, 15], energy feedback is primarily a human-related task needing user centered approaches for being tackled. Different kinds of feedbacks may be employed and they can either induce changes into home inhabitants habits or be completely ignored depending on many factors including users' green attitude, visual appearance, understandability of exposed data, etc. Among investigated mechanisms and visual solutions, the research community has currently reached a partial consensus on a set of basic interactions that are generally successful in promoting reductions in energy consumption. These solutions include:

- goal setting interfaces, i.e., interfaces based on users' desire of fulfilling a given (energetic) objective, either induced by the interface or self-imposed by home inhabitants;
- direct feedback, i.e., timely updated in-home displays (IHDs) showing the home current energy consumption;
- historical trends in consumption, showing how home consumption evolves over time and highlighting temporal correlations, e.g., in northern countries the winter season usually has higher consumptions;
- non-obtrusive displays, i.e., displays designed to weave themselves into the home environment, attracting the user attention when needed but avoiding intrusive settings and interactions that may foster interface abandoning or disposal.

Unfortunately, these interaction paradigms have been widely but sparsely investigated, and few approaches can be found, in the literature, that focus on the complete design process of IHDs, by applying user centered design principles from the early stage (interaction) to the final in-home deployment [11]. This paper is mainly focused on this topic and aims at evaluating the clarity and effectiveness of feedback mechanisms and the willingness of users to adopt interfaces implementing different types of electric energy consumption monitors.

The 2004 survey on "Consumer preferences for improving energy consumption feedbacks" [16] is one of the earliest works in this field. In this survey, carried by Simon Roberts, Helen Humphries and Verity Hyldon, focus group research is used to assess consumer preferences for feedback and improved information about energy consumption at home. A series of 7 focus groups in three different parts of England were held, dividing groups by bill payment methods. The study findings showed typical behaviors of home energy consumers, reporting interesting insights on the energy behaviors of the interviewed householders. In particular the study showed that home inhabitants:

- exhibit a high level of cynicism about the motivations of energy suppliers to promote energy saving and a general distrust in their advice;
- show high awareness and knowledge of energy saving measures and techniques but do not know the cost, and assume it is very expensive;
- demonstrate little motivation to act and high resistance to being forced to act;
- have very clear preferences (and dislikes) on feedback options;
- would, given the right feedback, examine reasons for change in consumption and may be stimulated to take actions.

Out of the focus group responses, equally strong preferences emerge for simple bar charts with historical data and direct consumption visualization. With respect to the survey reported in this paper, results are somewhat overlapping, showing users preferring simple and clear feedbacks. However the two works cannot directly be compared since the Roberts survey was mainly focused on paper-based feedbacks while in this study we are more concerned on real-time energy feedbacks.

G. Wood and M. Newborough [17] investigated the energy use information transfer in the home, with the aim of better enabling/fostering energy conservation through central and local displays. In their work, they analyze and discuss methods for motivating energy-saving behaviors and for presenting energy-use information on two different kinds of in-home displays. According to Wood studies, information alone about energy use in a room, by an appliance, in a time period, by an end user or during an activity will not motivate energy saving. Experimental evidence showed, in fact, that such information needs both to be displayed in a simple manner and appropriately grouped in order to motivate home inhabitants. Among several feedback opportunities, Wood and Newborough reported goal setting, self competition and monetary rewarding as the most effective interactions. On the converse, they demonstrated that expressing energy use in monetary units is not effective due to the small daily cost of consumed energy. Similar ineffectiveness is also shown by carbon dioxide and other environmental units to which home inhabitants are not accustomed, while the classical kWh energy measure is better accepted, although few people really understand this unit. The Wood study has been driving part of the design of the feedback mechanisms analyzed in this survey paper, especially the goal-setting feedback which lies at the basis of the designed feedback interfaces. Our survey results, in accordance to Wood's study, show that householders hardly understand energy usage in kWh and that they slightly prefer direct feedback based on power consumption (i.e., in kW).

Nevertheless, the effectiveness of in-home energy displays (IHD) is confirmed by the survey carried by Faruqui et al. [2] in May 2009. Faruqui et al., economists working with the Brattle Group, reviewed a dozen of pilot programs in North America, and abroad, either focusing on energy conservation impact of IHDs or that studied demand-side management tools and include IHDs as one of the tools. They also reviewed customer opinions and attitudes towards IHDs and direct feedback. Results show that direct power feedback provided by an IHD actually encourages people to make more efficient use of energy. Moreover, in their study, Faruqui et al., found that IHDs can reduce consumption of energy, on average, by about 7% when pre-payment of energy is not involved. Instead, when users are using IHDs and electricity prepaying systems they can reduce energy consumption by roughly 14%, on average. This confirms the increasing research attention on direct, real-time energy feedback systems and motivates the investigation carried in this paper.

On the same topic, Sarah Darby [18] carried a literature review on metering, billing and direct displays with the aim of better understanding the effectiveness of energy feedbacks to householders. According to Darby, overall literature demonstrates that clear feedback is a necessary element in learning how to control energy consumption more effectively over a long period of time, and that instantaneous direct power feedback in combination with frequent, accurate billing is needed as a basis for sustained demand reduction. Savings resulting from energy consumption feedback range between 5% and 15% in case of direct power feedback (the focus of the survey presented in this paper) and between 0% and 10% for indirect feedback, i.e., billing. According to Darby, user-friendly displays are needed as part of any new meter specification. Monitors will be most useful if they show instantaneous usage, expenditure and history feedback as a minimum, with a potential for showing information on micro-generation, tariffs and carbon emissions. Darby's work has inspired the design choices lying at the basis of the interfaces surveyed in this paper, which are explained in the next sections.

Besides energy efficiency, designing and evaluating IHDs has a strong human component which is currently attracting several efforts from the human-computer interaction research field. In the last years always-on electricity feedback, and implied issues, gained momentum in this community leading to several interesting approaches. Riche, Dodge and Metoyer [19], for example, conducted a study to understand consumer awareness of energy consumption in the home and to determine the requirements for interactive, always-on IHDs to gain awareness of home energy consumption. They then designed a three stage approach to support electricity conservation routines based on raising awareness, informing on complex changes and maintaining sustainable routines. Although not statistically significant, since the user group was too small, the results of their study highlighted several design suggestions/implications including the potential of location-based feedback for providing awareness and the necessary compromise between readability and aesthetics in always-on feedback. In this sense, this work and the interfaces surveyed in this paper have similar goals: finding the best trade-off between informational aspects and non-intrusiveness and aesthetics, with special regard to user needs and comprehension.

Tae-Jung Yun investigated the impact of a minimalist IHD [12] showing that even very simple visual feedback may have an impact on household consumption when combined with self-goal setting strategies on the part of the user, without any explicit goal setting interface. However, minimal solutions do not meet the needs of users who consider themselves to have high awareness of energy consumption in their homes, requiring more sophisticated interfaces. Our approach, in this sense, avoids shortcomings related to overly minimal approaches and focuses on more complete and complex interactions and on evaluating the user response to the proposed richer interfaces.

Psychological implications of energy displays and interaction paradigms may also influence the effectiveness of IHDs as demonstrated by the studies of He and Greenberg [13] and of Pierce et al. [14] remarking the importance of gathering, analyzing and responding to actual user needs during the design of feedback solutions. This user centered approach is actually driving the design of the survey discussed in the following sections, which takes care of analyzing user needs and acceptance of interfaces before moving to development of real displays.

3. Feedback, User Behavior and Saving Stategies

To understand how an in-home energy display may affect the home inhabitants habits, promoting positive changes in terms of energy efficiency and environmentally-friendly behaviors, it is important to frame the typical user behaviors related to energy consumption (or saving) and to understand the interaction paradigms lying at the basis of currently available solutions. The following subsections provide a brief overview of typical home user behaviors, with respect to energy saving, and the possible saving strategies that IHDs can exploit/induce.

3.1. Energy Saving Behaviors

Home displays aim at changing householders behavior to be more energy efficient and environmental friendly. Literature studies show that this increased energy efficiency can be achieved by acting on two distinct classes of behaviors: efficiency behaviors and curtailment [20]. Efficiency behaviors are typically performed once, e.g., by substituting an obsolete refrigerator with a new A+ class one, and their effects usually last for long periods of time (permanent or semi-permanent). On the other hand, curtailment refers to repetitive behaviors that householders adopt to reduce their energy consumption, e.g., turning off the personal computer when nobody uses it. Differently from efficiency behaviors, curtailment requires constant efforts by the home users and is typically targeted by most of IHD designs. Although its impact on the overall savings is generally lower than that of efficiency behaviors, it is still important because it does not require changes in the home environment and because it is subject to the rebound effect, which might invalidate saving efforts. The rebound effect occurs when a home inhabitant uses a new appliance much more than the older one, due to its higher efficiency. The end result is no overall change, or worse, an increase in energy usage.

3.2. Energy Saving Strategies

Many strategies have been proposed to tackle efficiency and curtailment behaviors, and they can be roughly categorized in 2 main families: *antecedent* and *consequent* strategies. Antecedent strategies are designed to induce or to avoid a user behavior, consequent strategies, instead, are designed to inform the user after the behavior occurred.

In the former category a sufficiently wide consensus [21, 22, 20] has been reached on: *Information*, *Goal setting* and *Commitment*. *Information* strategies provide residents with information and tips on how to reduce current energy consumption, how to select more energy efficient appliances, etc. *Goal setting* strategies exploit the natural competitiveness of humans to stimulate householders to reach a self-imposed (or interface suggested) energy goal, lower than the current energy consumption. *Commitment* strategies ask home inhabitants to explicitly commit to energy conservation measures. Although similar to goal setting, to which is often combined, commitment differs from goal setting on the psychological side: while goal setting pushes the user towards better behaviors, without requiring clear and voluntary acts, commitment requires users to explicitly and "rationally" adhere to energy reduction policies. Among antecedent strategies, goal setting reached a relatively wide consensus showing real potential to induce reductions in absorbed energy, from 2%-5% up to 20% [2].

Consequent strategies typically include 3 widely agreed approaches: *Feedback*, *Reward* and *Criticism*. *Feedback* shows residents how much energy they use; it can assume different forms and it must be easy to understand and immediate in its effects, i.e., users shall be enabled to immediately relate provided (visual) information with the corresponding home set-up. *Reward* consists in providing users rewards (monetary or social) for their good energy behaviors. Finally, *Criticism* is based on the idea of confronting users with surrounding people, passing judgments on them that depend on how well do they save energy in the home. This last mechanism proved to be rather unstable in its effects with many studies providing contrasting results. On the converse, feedback is widely recognized as a viable solution whilst reward has been relatively less investigated due to the difficulty of convincing energy providers to support monetary incentives for better energy behaviors and to the inability of finding reliable enough immaterial rewards such as reputation.

4. Survey Focus

In order to achieve successful results in guiding home users towards achieving sensible energy savings, we concentrate on the two strategies currently attracting more consensus: goal setting for what concerns antecedent strategies and feedback for consequent approaches. We consider the two approaches as complementary elements of the same interface concept[3], with the aim of teaching users how to best perform with respect to efficient energy consumption. While goal setting aims at preventing bad behaviors by imposing a competitive "pressure" on the home inhabitant, feedback aims at supporting the home user in understanding its current behavior, in highlighting wrong or not-efficient habits and in taking the needed corrective actions.

In-home displays showing energy consumption require a set of basic assumptions on the home environment in which they are installed: the presence of one, or more, energy or power meters, the possible availability of home automation devices, the display size and placement, etc. The survey presented in this paper is based on the following assumptions:

- the availability of one meter per room or of an equivalent metering system able to provide measurements at room-level granularity;
- the availability of a home automation plant able to detect and report home device activations;
- the availability of a medium-sized (e.g., 7" or greater) display hardware.

By building on top of this hypothetical but realistic home set-up, we define two different visualizations sharing the same visual layout (shown in Figure 1, where only one interface is presented as the layout and visual appeal of both visualizations is very similar) and focused respectively on direct power feedback (DPF) and energy goal setting (EGS).

Interface features common to both visualizations include: (a) a clock display showing the current time: this allows users to correctly perceive time and permits to correlate interface changes with the corresponding temporal information; (b) a colored home map showing the home rooms in color nuances ranging from green (good performance) to red (bad performance), depending on the current power or energy consumption; (c) a numeric indicator reporting the electric power currently absorbed by the home, colored from green to red as the consumed power approaches the maximum power allowed for the home[4]; (d) a couple of numeric displays showing the energy goal to be reached in a day (or in a week) and the currently consumed energy, also in color hues ranging from green (good) to red (consumed energy approaching or exceeding the current goal).

Room coloring on the home map is dictated by two different algorithms: a direct power feedback strategy (DPF) relating the power currently consumed in a room with the maximum power

[3] Even though more strategies can be combined together, we deliberately choose to adopt only two strategies in order to avoid information overload, which might inhibit positive results as pointed out by Wood and Newborough [17].

[4] i.e., the maximum power permitted by the delivery contract.

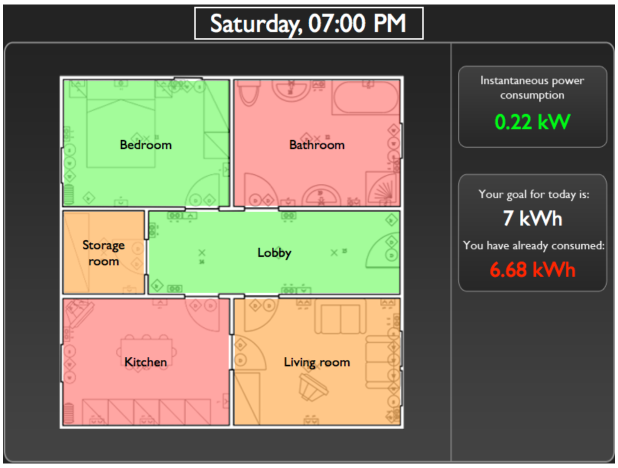

Figure 1: The proposed visualization layout.

allowed for the whole home, and a goal setting strategy (EGS) where room color information depends on how currently consumed energy is distributed among rooms, with respect to the energy goal set for the whole home.

In both cases, we first define the fraction $F(r)$ of power consumption allocated to a room r from the set of all rooms R. Such fraction takes into account the set of devices installed in the room (or that may be used within the room), compared to the whole house. In the current experiments, the room fraction $F(r)$ has been computed according to (1), where D is the set of all devices d, and is partitioned among devices that can me moved across rooms D_m (e.g., the vacuum cleaner) and devices permanently installed in a room r: $D_f(r)$. $P_D(d)$ is the nominal power of a device $d \in D$ and $|R|$ is the number of rooms in the home.

$$F(r) = \frac{\sum_{d \in D_f(r)} P_D(d) + \frac{\sum_{d \in D_m} P_D(d)}{|R|}}{\sum_{d \in D} P_D(d)} \tag{1}$$

In the DPF case, every room is assigned a share of maximum power $P_R(r)$, computed by scaling the maximum allowed power for the home P_M by the room fraction $F(r)$, as in equation (2).

$$P_R(r) = P_M \cdot F(r) \tag{2}$$

At runtime, every room in the home map changes its color (green, orange, or red) depending on the ratio of its actual current power consumption $P_A(r)$, compared with the room power share $P_R(r)$, according to easy to tune thresholds (3).

$$\frac{P_A(r)}{P_R(r)} \in \begin{cases} [0, \alpha)\,, & \text{green} \\ [\alpha, \beta)\,, & \text{orange} \\ [\beta, 1]\,, & \text{red} \end{cases} \tag{3}$$
$$0 < \alpha < \beta < 1$$

In the presented survey α was chosen as equal to 0.4 and β equal to 0.8. Other values may be selected, as well; the survey is, in fact, designed to have a low sensitivity of results with respect to these tunable parameters.

In the EGS case, i.e., the energy goal setting strategy, every room on the home map changes color depending on the amount of energy consumed in the room with respect to the goal quota assigned to the room. Given the overall energy goal E_G assigned to the home over a time period, every room is assigned a goal quota $E_R(r)$ proportional to the room fraction $F(r)$, as in (4). Similarly to the power case, the energy consumed by each room, during the goal validity time frame, is compared with the goal quota assigned to the same room and the resulting color hue is computed using the same threshold policy used in the direct power feedback visualization.

$$E_R(r) = E_G \cdot F(r) \tag{4}$$

4.1. Reference scenario

To better illustrate the two strategies reported in the previous subsections, we have built two short videos to be used in our web-based survey. The two videos are based on the same house model. The modeled house is a flat composed of six rooms: a kitchen, a bathroom, a living room, a lobby, a bedroom and a storage room. Rooms contain different devices and appliances, whose power consumption is reported in Table 1. Moreover, there is a "mobile" electric device (i.e., the vacuum cleaner) that is considered differently from the other statically installed appliances. We are aware that the environment appliances listed in Table 1might change depending on different cultural contexts. However, in this study, we are mainly interested in evaluating the proposed interaction paradigms, and the user reactions to the provided feedback information. In simpler terms, it does not matter too much what specific consumption users see, but how they perceive it and how they react to the provided information.

Table 1: Devices and appliances present in the house model, with their consumptions

Rooms	**Devices**	**Consumption**
Kitchen	Electric Oven	2200 W
	Microwave Oven	700 W
	Fridge	150 W
	Neon Lamp	11 W
	Dishwasher	1200 W
	Coffee Maker	1000 W
	TV	60 W
Bathroom	Washing Machine	2250 W
	Lamp	15 W
Living Room	Stereo	80 W
	Lamp	15 W
	DVD Reader	20 W
	TV	60 W
Lobby	Lamp	15 W
Bedroom	Ceiling Lamp	80 W
	Alarm Clock	7 W
	Notebook	70 W
Mobile	Vacuum Cleaner	1500 W

Power figures reported in Table 1reflect realistic device consumptions extracted from the "Your Electric Appliances" report, edited by *Seattle City Light*[5]. For devices not present in the Seattle City Light's list, we have acquired nominal wattage from real appliances installed in our homes.

4.1.1. Direct Power Feedback

The video[6] showing the behavior of our house model in the "direct power feedback" case, represents a typical day in the life of flat inhabitants, where the maximum power available in the house is 3 kW. The video lasts 1 minute and 50 seconds and covers different activations all day long. We present devices' activations for 5 minutes every six hours (focus points), accelerated 12 times to maintain the video (and the entire questionnaire) as short as possible. In the hours between every focus point, devices keep turning on and off, thus motivating rooms color changes.

As an example, consider the following video fragment: at 12:00 PM, the rooms in the IHD are green and the total instantaneous power used in the house is 160 W; the only active devices are the fridge and the alarm clock. At noon, someone turns on the TV and the microwave oven in the kitchen. At 12:01 PM, the IHD shows the kitchen colored in orange and the total power consumed is 760 W, when the fridge consumes less. This situation persists until 12:05 PM. The entire video storyboard is summarized in Table 2, where room names are abbreviated, and G represents the green, O the orange and R the red colors.

Time	**What happens?**	**Room colors**					
		Kit.	*Liv.*	*Bat.*	*St.*	*Bed.*	*Lob.*
06:00 AM	Someone turns on the lamp and the coffee maker in the kitchen	G	G	G	G	G	G
06:01-06:05 AM	The lamp and the coffee maker are active	O	G	G	G	G	G
12:00 PM	Someone turns on the TV and the microwave oven in the kitchen	G	G	G	G	G	G
12:01-12:05 PM	The TV and the microwave oven are active	O	G	G	G	G	G
06:00 PM	Someone turns on the washing machine in the bathroom	G	O	O	G	G	G
06:01-06:04 PM	The washing machine and the other devices previously on are still active	G	O	R	G	O	G
06:05 PM	The washing machine starts to consume less power	G	O	O	G	O	G
The fridge and the alarm clock are always active. The fridge cycles its power consumption every minute.							

Table 2: The video storyboard for the instantaneous power visualization

[5] `http://www.seattle.gov/light/conserve`

[6] see Video 1 in the paper supplementary material.

4.1.2. Energy Goal Setting

The video[7] reporting the behavior of the house model in the goal setting representation shows a typical day in the same household of the previous case, where the daily energy goal is set to 7 kWh. The video lasts 1 minute and covers different activations all day long. In particular, we present a "snapshot" of the energy consumption in the house each hour. Moreover, to better appreciate the energy variation occurring in the house, we show the first 2 minutes every six hours (accelerated 12 times, as before). In the other hours some devices turn on/off, inducing changes in the rooms colors. This difference of shown time interval, compared to direct power feedback visualization, is needed for better representing the daily evolution of our house model.

As an example, consider the following scenario: at 07:00 PM, the previously switched on washing machine and notebook are turned off. At the same time, in the kitchen, the lamp and the TV are turned on. The total amount of energy used in the house up to this moment is 6.68 kWh. The bathroom and the living room change color: the former becomes red while the latter is orange. This situation remains the same up to 09:00 PM. On the end of the day, the house inhabitants will exceed the daily goal. The entire video storyboard is summarized in Table 3.

5. Survey design and planning

The definition of the type of feedback and the information to show to users, allowed us to design a web-based questionnaire to collect opinions and needs of home inhabitants. The primary reason for this approach, as opposed to face-to-face or telephone interviews, was that we aimed at reaching as many people as possible while maintaining costs as low as possible, letting users to answer our questions in their preferred times.

Our survey was localized both in Italian and in English, and was kept open from September 27, 2010 up to January 31, 2011. It required about 15 minutes for completion. The questionnaire targeted technology-aware participants with a normal domestic life experience. No particular knowledge about energy consumption and measurement were required. For this reason, the survey was announced via emails and social networks (e.g., Facebook, Twitter, LinkedIn, etc.) to colleagues and friends, on the students mailing list of some universities and on the ACM CHI-WEB mailing list. By using these distribution methods, we expected to reach a significant number of people, in Italy and abroad.

5.1. Survey form

To encourage high survey participation and completion, we carefully considered the global design of the survey, the formulation of the asked questions and the layout of these questions. Survey replies were anonymous and each respondent could complete the questionnaire once. To reduce misunderstandings due to language barriers we decided to build two versions of the same questionnaire: one in Italian and the other in English. This choice allowed Italian people without fluent knowledge of the English language to successfully understand and complete the survey.

Questions were divided in 4 groups and, for each question in a group, a set of 4 to 5 answers were provided with at least one answer completely wrong and one completely right. Questions involving aspect that we felt critical for the survey success were usually duplicated in different forms, to cross-check answers, and suggested responses allowed for a certain degree of flexibility in the answering process, supporting partially right or partially wrong statements.

[7] see Video 2 in the paper supplementary material.

Time	What happens?	Room colors					
		Kit.	*Liv.*	*Bat.*	*St.*	*Bed.*	*Lob.*
00:00 - 05:00 AM	Everything is off*	G	G	G	G	G	G
06:00 AM	Someone turns on the lamp and the coffee maker in the kitchen	G	G	G	G	G	G
07:00 AM	The coffee maker in the kitchen is turned off	G	G	G	G	G	G
08:00 AM	The lamp in the kitchen is turned off	G	G	G	G	G	G
11:00 AM	Someone turns on the TV and the oven in the kitchen	G	G	G	G	G	G
12:00 PM	The TV is still active and the microwave oven is turned on	O	G	G	G	G	G
01:00 PM	The TV is still active and the coffee maker is turned on for 12 minutes	O	G	G	G	G	G
02:00 PM	The dishwasher is turned on for one hour	R	G	G	G	G	G
03:00 PM	The vacuum cleaner is turned on for 5 minutes in each room	R	G	G	G	G	G
04:00 PM	The TV in the living room is turned on	R	G	G	O	G	G
05:00 PM	The TV in the living room is still on and the notebook is turned on	R	G	G	O	G	G
06:00 PM	The TV in the living room is turned off, the notebook is still on and the washing machine is turned on	R	G	G	O	G	G
07:00 PM	The TV and the lamp in the kitchen are turned on	R	O	R	O	G	G
08:00 PM	The TV and the lamp in the kitchen are still on for this hour	R	O	R	O	G	G
09:00 PM	The dishwasher in the kitchen the TV and the lamp in the living room, the lamp in the bathroom are turned on	R	O	R	O	G	G
10:00 PM	The TV and the lamp in the living room are still on, and the lamp in the bedroom is turned on	R	O	R	O	G	G
11:00 PM	Everything is turned off*	R	O	R	O	O	G
*The fridge and the alarm clock are always active.							

Table 3: The video storyboard for the goal-based (energy consumption) visualization

Our questionnaire was composed of an introductory description followed by the four question groups:

1. *Warm up...*, to collect some personal information;
2. *Direct power feedback*, to collect information about the IHD showing DPF information;
3. *Energy Goal setting*, to collect information about the IHD showing EGS data;
4. *Final rush...*, to collect users' preferences and suggestions.

The next subsections detail the different group contents. Questions reported in the following tables and marked with "M" are *mandatory*; the ones marked with "O" are *optional*, and the ones marked with "A" are *alternative* to each other, i.e., they are randomly shown to different users.

5.1.1. Warm up...

In this question group, we gathered some demographic information, such as age, job and country where users live (Table 4). The answers in this group are free text, except for the gender.

Warm up...	
1. How old are you?	M
2. Gender?	M
3. What is your job?	M
4. Where do you live? Please, write the country.	M

Table 4: The questions proposed in the "Warm up" group

5.1.2. Direct power feedback

For this group, users were asked to first watch the video showing DPF information about our house model. After the video, they have to reply to six questions (Table 5), all with multiple choice answers. Questions marked as "alternative" are presented in a random order, two at a time.

We expected participants to be able to understand all the implicit and explicit activations of the devices in our house model, by carefully watching the video. Moreover, users should be able to estimate the maximum power allocation defined for the house and understand how the consumption changes. Questions 4-6 referred to people's understanding of room colors. We suppose that most participants are able to comprehend why a room becomes green, orange or red.

5.1.3. Energy Goal setting

For this group, users were required to watch the video reporting EGS data gathered from our house model during all day long. After the video, they have to reply to 14 questions (Table 6), all with multiple choice answers. Questions 4 and 5 are randomly chosen from three alternatives; also question 6 is chosen randomly. Due to the similarity between the two interfaces, before starting this questions group, a "separation" page was shown to participants, to explain them that the video presented in this group is different from the previous one. We inserted this page after a

Direct power feedback	
1. What could be the maximum power allocation defined for the home in the video?	M
2. When was the power consumption highest?	M
3. What appliance consumed most power?	M
4/5. A room is green if…	A
4/5. A room is red if…	A
4/5. A room is orange if…	A
6. Do the red, orange and green colors help you to understand how much you are consuming?	M

Table 5: The questions proposed in the "Direct power feedback" group

preliminary trial of the web-based survey, where users did not always realize that the video was changed.

We expect that most participants:

- understand the goal-setting strategy;
- comprehend whether and when energy consumption increases or exceeds the goal;
- understand why and how the rooms change colors;
- evaluate the utility of such visualization to improve their energy behavior.

Moreover, we ask for suggestions about how the IHD should define the "goal of tomorrow" if the goal of today was (or was not) exceeded; and whether the IHD should reward them when the energy consumption is lower than the goal.

Energy Goal setting	
1. What is the daily energy consumption that must be respected?	M
2. Does the actual daily energy consumption exceed the predefined limit?	M
3. When does the energy consumption increase?	M
4/5. A room is green if…	A
4/5. A room is red if…	A
4/5. A room is orange if…	A
6. In the previous question, what do you mean for "a little"?	A
6. In the previous question, what do you mean for "a lot"?	A
7. Do you think that every room changes its color with the same energy consumption values?	M
8. How do rooms change color?	M
9. Do the green, red and orange colors help you in understanding how you are behaving with respect to your energy goals?	M
10. If today I've met my energy consumption goal, how shall the goal of tomorrow be defined?	M
11. Do you think that the next energy consumption objective shall take in account how much you exceeded the goal for today?	M
12. How do you like to take into account the energy consumption excess?	M
13. Do you think you shall be rewarded when your energy consumption is lower than the daily objective?	M
14. How do you like to be rewarded?	M

Table 6: The questions proposed in the "Energy Goal setting" group

5.1.4. *Final rush…*

In this question group, we asked for suggestions and preferences about the two visualizations and the IHD in general (Table 7). Participants have to reply to five questions, in this group. In the end, we asked for general suggestions and preferences about the presence of an IHD in the house. The answers in this group are either free text or multiple choice.

Final rush…	
1. With reference to the previous clips, which of the two interfaces would you like to have in your home?	M
2. What interface would motivate you to reduce your energy consumption?	M
3. Would you like to have this screen in your home?	M
4. Where, in your home, would you like to install the screen showing this interface?	M
5. Suggestions? Comments?	O

Table 7: The questions proposed in the "Final rush…" group

6. Results

1807 people participated in the survey. 992 completed the questionnaire while 815 did not, thus the overall completion rate was 54.89%. No follow-up techniques were applied to reduce the amount of non-answering participants. Most of people who did not complete the survey answered the first two groups of questions and started the third, but did not continue presumably because they underestimated the duration of the survey and decided to interrupt it or because they did not understand the differences between the first and the second video, and therefore refused to provide duplicate answers. Their answers are not part of the results and the discussion reported in this paper.

The questionnaire is based on an open sample of people and, as such, the results cannot be proven to be representative of any given population. But with nearly 1000 responses collected, "patterns can be identified and cross-discipline analysis is possible" [15].

The majority of people that finished the survey are from academia (76%), with the rest coming from industry. Most academic people are students at Politecnico di Torino (88%) having an educational background mainly focused on engineering, architecture and industrial design. Participants are aged from 18 to 70 years (M: 23, SD: 8.36); 686 (69.15%) are male, while the other 306 are female. Most of the users come from Western countries, in particular: 945 people come from Italy (95.26%), 15 from Spain (1.51%), 8 from Finland (0.81%) and 7 from the United States (0.71%), as reported in Table 8.

Country	**# participants**	**% participants**
Italy	945	95.26%
Spain	15	1.51%
Finland	8	0.81%
United States of America	7	0.71%
France	5	0.50%
Others	12	1.2%

Table 8: The country of the questionnaire participants

Next subsections will discuss survey results, divided by group at a question-level granularity (see Appendix Appendix A for finer details).

6.1. Direct Power Feedback

Questions of this group were about instantaneous power consumption visualization (see Table 9in Appendix A for more details). When asked, after watching the first video, *"What could be the maximum power allocation defined for the home in the video?"*, 50.81% of our respondents correctly answered "3 KW". Since no evidence of this value is reported in the video, the number had to be estimated by looking at the color of the total consumed power. The total power consumption indicator, in the video, becomes red when it reaches 2.67 kW, at 06:02 PM. This behavior suggests that the maximum power could be around 3 kW. For this reason, we consider "reasonably correct" also the reply "2.7 kW", given by 32.56% of our respondents. The total percentage of correct replies was 83.37% and fits our expectations.

The next question, *"When was the power consumption highest?"* was answered correctly by 92.54% of the participants, who identify the maximum power consumption between 06:00 and 06:05 PM. The same happens with the third question: *"What appliance consumed most power?"*, where 94.56% of our respondents identify the washing machine as the most power consuming appliance. These preliminary replies suggest that almost all the participants understood where to find this information and how to read it.

The next set of questions looks for changes in room colors. Each participant was randomly shown two of the questions: *"A room is green if..."*, *"A room is orange if..."* and *"A room is red if..."*. 71.56% of respondents of the first question answered nearly correctly ("Nothing is on") while the 26.30% answered correctly "Something is on and it has a low consumption". Even if the second reply is the best, the former is not totally incorrect since, in the video, rooms are green with no appliances turned on. Things go better with the second question, where 53.87% of the respondents answered correctly "Something is on and it consumes a bit". A significant portion of the participants (36.68%) answered "Something is on and it has a low consumption". For our purpose, we also considered correct this answer, mainly to account the ambiguity of the terms "a bit" and "low". The same ambiguity is much lower for the last question ("A room is red if...") and this is reflected by the high percentage of correct replies (85.71%). In all questions belonging to this set respondents perceived the general difference between room coloring, as expected.

The last question of this group asks for an opinion about the color-based visualization: *"Do the red, orange and green colors help you to understand how much you are consuming?"*. 71.77% of respondents answered "Yes" and 25.40% said "A bit". We imagined an higher number of positive replies for this question but we consider satisfactory the resulting figures, especially if compared with the negative replies (2.82%).

6.2. Energy Goal Setting

Questions of this group were about goal-based visualization, on energy consumptions (see Table 10in Appendix A for more details). After watching the video, we asked *"What is the daily energy consumption that must be respected?"*. 92.44% of our respondent correctly answered "7 kWh". This value, however, is clearly reported in the video, thus being easy to spot.

The following question, *"Does the actual daily energy consumption exceed the pre-defined limit?"*, was answered correctly by 94.56% of participants. The same happens with the next question: *"When does the energy consumption increase?"*, where 52.82% of our respondents answered “When a new device is switched on” and 44.46% answered “Only if there are active devices”. We considered both questions as correct, since the energy consumption increased in both cases. These preliminary replies suggest that almost all the participants understood where to find this information and how to interpret it.

6.2.1. Room Colors

The next set of questions looks for changes in room colors, similar to the previous question group. Each participant has been randomly presented two of the questions: *“A room is green if. . . ”*, *“A room is orange if. . . ”* and *“A room is red if. . . ”*. 78.29% of respondents of the first question answered correctly “Until now, the devices located in the room have consumed a little”. More or less, the same happens with the second question, where 60.70% of participants gave the correct answer (“Until now, the devices located in the room have consumed quite a bit”). As for the previous question group, we considered both answers as correct, due to the ambiguity of terms “quite a bit” and “a little”. Such ambiguity is really lower for the last question (“A room is red if. . . ”) and this fact is confirmed by the higher percentage of correct answers (80.42%). Respondents, for this set of three questions, perceived the general difference in the room coloring, as expected.

To better understand what people mean when choosing “a little” or “a lot”, we asked a further question, randomly chosen from *“In the previous question, what do you mean for ‘a little’?”* and *“In the previous question, what do you mean for ‘a lot’?”*. In the survey design, the two quantifiers (“little” and “a lot”) corresponded to respectively less than the 40% of the daily consumption goal for the room, and to more than the 80% of the same goal. Only 43.28% of respondents answered correctly to the first question (“Less than the energy consumption objective associated to the room”). 41.30% answered “Less than 1 kWh”. Even if this answer was not totally correct, in the example shown in the video, all the rooms are green when the energy consumption is lower than 1 kWh. This fact, probably, indicates that several users did not totally understand the correct algorithm but they understood the behavior presented in the example, and deduced the answer from the video.

For the second question, 62.47% of our respondents answered correctly “More than the energy consumption objective associated to the room”. A significant portion of answers (21.17%) were “More than 3 kWh”, again suggesting that these users did not completely understand the correct algorithm but they understood the behavior presented in the video since, for example, the kitchen becomes red when its energy consumption is higher than 3.1 kWh. In our opinion, the percentage of users answering correctly is higher than before because it is easier to mark the alternative answers as “wrong”, by observing the behavior of the room coloring in the video.

At this point, we asked participants *“Do you think that every room changes its color with the same energy consumption value?”*. 68.55% of respondents said “No”, that is the correct answer. However, 18.04% answered “Yes”, while 13.41% said “May be”. The next question, *“How do rooms change color?”* had again two acceptable answers. Most users chose one of these answers. In particular, 50.40% of respondents chose the most correct answer (“On the basis of the total energy objective referred to a single room”), while 26.71% said “On the basis of the energy consumed until now” that is a little less correct but is not a wrong answer since each room changes its color according to the energy consumed inside it.

The next question of this group asks for an opinion about the color-based visualization: *“Do the red, orange and green colors help you in understanding how much you are behaving with respect to your energy goals?”*. 43.35% of respondents answered “Yes” and 43.55% said “A bit". Such a result is in accordance to our expectations, due to the "complexity" of the EGS visualization, especially if compared with DPF.

6.2.2. Goal of Tomorrow

The last five questions were not directly related to the video but they concerned the "goal setting for tomorrow". How shall it be defined? Shall it take into account how much the user exceeded the goal for today? How? Shall you be rewarded when your consumption is lower than the daily goal? How?

Participants had different ideas. 65.02% of our respondents said that if they met the goal for today, the goal of tomorrow should be lower. This answer could suggest an attempt to improve their personal energy-saving behavior. However, 32.56% of users said that if they met the daily goal, the objective for tomorrow should be equal. When asked *"Do you think that the next energy consumption objective shall take into account how much you exceeded the goal for today?"*, 72.58% said "Yes" and 8.67% answered "May be". The 806 respondents that provided positive responses to the previous question, however, did not have convergent opinions on how take in account the energy consumption excess. In fact, 37.27% of them said that the new goal should be decreased with a part of today's excess; 29.81% said that the new goal should be decreased with the entire today's excess; 19.25%, finally, would have increased the new objective by a part of today's energy excess. It is interesting to notice that more than 60% of these respondents would decrease the goal, thus "punishing" themselves to have exceeded the daily quota.

We also collected participants' opinions about a reward to give them if they met (or over-met) their daily goal. 54.13% of our respondents said that they did not want a reward; only 36.59% said "Yes". 33.49% of respondents who asked for a reward said that they would decrement the new goal by a part of the energy saved; 17.09% would decrement the new goal by the entire quota of energy saved today; 16.40% would increment the new objective by a part of the energy saved. 25.28%, however, suggested other rewards. The most popular suggestion was an economical reward, on the final price of the energy bill.

6.3. Final rush...

The last question group asked users for opinions, preferences and general suggestions. In the first question, we collected a preference about which interface (DPF and/or EGS) users would like to have in their homes. 47.98% of respondents expressed the desire of having both interfaces, 28.83% chose DPF (the former) and a nearby percentage (21.37%) EGS. Only a small group of persons answered that they would not like to have any interface in their homes (1.81%). This absence of bias between the two interfaces was not preserved when asking participants *"What interface would motivate you more to reduce your energy consumption?"*. 49.90% answered "Goal (energy consumption)" interface and 36.49% the other one. Only a 13.61% said that the two interfaces are equivalent. Even if almost half respondents would like to have both interfaces in their home, a larger subset thought that the EGS visualization could improve their "green behavior" more than DPF.

Next questions referred to whether and where participants would have an IHD in their homes. 37.30% of respondents would have an IHD screen, if possible; 31.25% probably would have; 24.19% think that they absolutely need such a screen; only 7.26% would not have any IHD. Regarding the location of the screen, most users reported more than one room. In particular, the most frequently mentioned room was the kitchen (32.66% of preferences), followed by the lobby/corridor (20.44%). The third preference went to a generic "most popular room" (13.36%).

It is interesting to notice that 4.19% of preferences regarded portable devices or integration with pre-existent appliances, but only 1.40% of replies explicitly indicated the "most consuming room" as a good location for such displays. Even the bathroom/laundry collected few preferences (1.66%).

The last question asked participants for comments and suggestions (if any). The most interesting replies are reported and discussed in the next Section.

7. Discussion and User Comments

The objectives of our questionnaire were to understand if people like IHDs and comprehend energy goal setting or direct power feedback visualizations. Our survey results indicate that most of our respondents would adopt an in-home display, thus demonstrating a strong motivation to save energy. About half of them would like to have both visualizations in their IHD, but they prefer the energy goal setting one if the final objective is to improve their green behavior. It seems that direct power feedback visualization is more useful for checking the presence of turned on appliances that nobody uses and for avoiding to exceed the maximum power allocation for the home, while energy goal setting is better for improving energy consumption and the personal green behavior. Results also show that color-based feedback is easily understood and well appreciated, especially in the DPF case; moreover, the direct power feedback visualization appears to be easier to understand than the energy goal setting one.

Regarding the location of an IHD in the house, most users suggest to place it in the kitchen or in the lobby. Two trends emerge from the comments gathered by this question: about half of respondents, in choosing a location, looked for a visible and central place, while the others suggested places less visible but "esthetically acceptable," for example by indicating to put the IHD near the electricity control system (i.e., energy meter and/or circuit breaker). Other users suggested to have the direct power feedback visualization in every room (or on a portable device, such as a PDA, a smartphone or a digital picture frame), and the energy goal setting only in one room, with a dedicated screen. Moreover, the few participants that suggest to put the IHD in the bedroom stress the educational aspect of energy and power saving, especially for their children.

The last question of our web-based survey looks for general comments and suggestions. Omitting the comments about the questionnaire itself (most of them are positive) and the difficulties experienced by some participants in understanding the behavior of the EGS visualization, it is possible to gather suggestions in the following ten sentences, ordered by popularity:

1. report the partial power/energy consumption for each room, also numerically;
2. realize an joint interface for both visualizations;
3. offer the possibility to set a goal not only on a daily base, e.g., weekly;
4. offer a power/energy consumption history;
5. offer control of appliances;
6. add an alarm to report when the circuit breaker is near to be activated;
7. give hints about how to improve current green behavior in both visualizations;
8. provide appliance-level detail for instantaneous power consumption data;

9. take into account, in the EGS visualization, recurrent behaviors and seasonal patterns;
10. give the possibility to set custom goals at the room level.

The most notable concept in this list is that almost all suggestions are about the energy goal setting visualization: only two of them regard solely the direct power feedback interface. The first comment (the most popular) suggests to report the energy and power consumption for each room, not only with colors but also with a numerical value. This request for more details at room level could suggest some difficulties in the color-based visualization whose behavior could be clearer by adding some details about the single room.

The second suggestion is related to the fact that about half of our respondents would like to have both interfaces.

The third comment is about goal duration: users prefer to work with weekly or monthly goal. This option was already considered in the interface design, but does not appear in the shown video: with a weekly goal, the video would have been too long.

Next comments regard possible improvements of our visualizations, to be exploited in future work. The most interesting improvement is the request for a consumption history, to maintain separately for both visualizations (#4) and to integrate with the energy goal setting (#9). The request for hints to improve users energy behavior (#7) and the suggestion to extend the interface by including the control of (smart) appliances (#5), so that users could act on various devices as soon as they see single appliance consumptions in the IHD, are interesting. The last suggestion, in particular, confirms the relevant role of home automation in saving energy at home.

8. Conclusion and Future Works

This paper presents a web-based questionnaire with the main goal of validating the interaction paradigms of direct power feedback and energy goal setting visualizations against the needs of a wide user base (992 users) of people living in a home, and habitually using basic web technologies such as a web browser or an e-mail-reading program (technology-aware). Results show that most respondents would like to have an IHD in a central place of their home and that they understand and accept both direct feedback and goal setting visualization, even if they feel the latter more useful for reducing their energy consumptions.

Room-level detail proposed by both visualizations proved to be interesting, on one hand, but on the other hand it showed some shortcomings, especially in the goal-setting visualization, where more "precise" (numeric) feedback was required by most of survey respondents. This motivates further research on level-of-detail aspects.

Interesting insights resulted from the question group about the "goal of tomorrow", i.e., about which policy might be better to set-up the next goal when a goal validity time expires. First it is rather clear that people are not really aware of how to set and modify such a goal, although they are kind to commit to greener behaviors. Second, it is surprising that such a commitment is reflected in setting more stringent goals even when the just-ended one was missed. Monetary rewards still preserve some attraction but most of people participating in the survey would improve their energy efficiency for free.

Future work will focus on the refinement of the algorithms behind direct power feedback and energy goal setting visualizations and on the implementation of an interface for energy consumption awareness, including features resulting from the survey.

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Appendix A. Detailed Survey Results

Table A.9: Results for the Direct Power Feedback questions group

1. What could be the maximum power allocation defined for the home in the video?	1.5 KW	1.71%
	6.0 KW	9.38%
	2.7 KW	32.56%
	3.0 KW	50.81%
	I don't know	5.54%
2. When was the power consumption highest?	From 6:00 a.m. to 6:05 a.m.	0.81%
	From 12:00 p.m. to 12:05 p.m.	2.62%
	From 6:00 p.m. to 6:05 p.m.	92.54%
	None of the others	4.03%
3. What appliance consumed most power?	The dishwasher	2.22%
	The washing machine	94.56%
	The fridge	2.22%
	The coffee maker	1.01%
4/5. A room is green if…	Nothing is on	71.56%
	Something is on and it has a low consumption	26.30%
	Something is on and it consumes a bit	1.22%
	What is on consumes a lot	0%
	No answer	0.92%
4/5. A room is red if…	Nothing is on	0%
	Something is on and it has a low consumption	0.30%
	Something is on and it consumes a bit	12.46%
	What is on consumes a lot	85.71%
	No answer	1.52%
4/5. A room is orange if…	Nothing is on	0.57%
	Something is on and it has a low consumption	36.68%
	Something is on and it consumes a bit	53.57%
	What is on consumes a lot	7.74%
	No answer	1.15%
6. Do the red, orange and green colors help you to understand how much you are consuming?	Yes	71.77%
	No	2.82%
	A bit	25.40%

Table A.10: Results for the Energy Goal Setting questions group

1. What is the daily energy consumption that must be respected?	1 kWh	0.71%
	3 kWh	4.74%
	5 kWh	2.12%
	7 kWh	92.44%
2. Does the actual daily energy consumption exceed the predefined limit?	Yes	94.56%
	No	4.03%
	Maybe	1.41%
3. When does the energy consumption increase?	When a new device is switched on	52.82%
	Only if there are active devices	44.46%
	When a device is switched off	2.72%
4/5. A room is green if…	I haven't consumed anything	11.01%
	Until now, the devices located in the room have consumed a little	78.29%
	Until now, the devices located in the room have consumed quite a bit	0.92%
	Until now, the devices located in the room have consumed a lot	1.53%
	The consumption meter is still green	7.03%
	No answer	1.22%
4/5. A room is red if…	I haven't consumed anything	0.90%
	Until now, the devices located in the room have consumed a little	2.11%
	Until now, the devices located in the room have consumed quite a bit	12.05%
	Until now, the devices located in the room have consumed a lot	80.42%
	The consumption meter is still red	3.61%
	No answer	0.90%

Question	Replies	Percentage
4/5. A room is orange if. . .	I haven't consumed anything	2.35%
	Until now, the devices located in the room have consumed a little	19.94%
	Until now, the devices located in the room have consumed quite a bit	60.70%
	Until now, the devices located in the room have consumed a lot	10.56%
	The consumption meter is still orange	4.99%
	No answer	1.47%
6. In the previous question, what do you mean for "a little"?	Less than 1 kWh	41.30%
	Less than 3 kWh	12.65%
	Less than the total energy consumption objective (7 kWh)	2.37%
	Less than the energy consumption objective associated to the room	43.28%
	No answer	0.40%
6. In the previous question, what do you mean for "a lot"?	More than 3 kWh	21.17%
	More than 5 kWh	4.40%
	More than the total energy consumption objective (7 kWh)	11.11%
	More than the energy consumption objective associated to the room	62.47%
	No answer	0.84%
7. Do you think that every room changes its color with the same energy consumption values?	Yes	18.04%
	No	68.55%
	Maybe	13.41%
8. How do rooms change color?	On the basis of the energy consumed until now	26.71%
	On the basis of the total energy consumption objective	7.76%
	On the basis of the total energy consumption objective referred to a single room	50.40%
	On the basis of devices being switched on	13.61%
	No one of the others	1.51%

Question	Replies	Percentage
9. Do the green, red and orange colors help you in understanding how you are behaving with respect to your energy goals?	Yes	43.53%
	No	13.10%
	A bit	43.55%
10. If today I've met my energy consumption goal, how shall the goal of tomorrow be defined?	Equal to today's objective	32.56%
	Lower than today's objective	65.02%
	Higher than today's objective	2.42%
11. Do you think that the next energy consumption objective shall take in account how much you exceeded the goal for today?	Yes	72.58%
	No	18.75%
	Maybe	8.67%
12. How do you like to take into account the energy consumption excess?	Decreasing the new objective with the whole today's energy excess	29.81%
	Decreasing the new objective with a part of today's energy excess	37.27%
	Increasing the new objective with the whole today's energy excess	8.57%
	Increasing the new objective with a part of today's energy excess	19.25%
	Other	5.09%
13. Do you think you shall be rewarded when your energy consumption is lower than the daily objective?	Yes	36.59%
	No	54.13%
	Maybe	9.27%
14. How do you like to be rewarded?	Increasing the new objective by the entire energy saving achieved today	7.74%
	Increasing the new objective by a part of the energy saving achieved today	16.40%
	Decreasing the new objective by the entire energy saving achieved today	17.08%
	Decreasing the new objective by a part of the energy saving achieved today	33.49%
	Other	25.28%