A Study on Persuasive Applications for Electric Energy Saving

Un Hee Schiefelbein[1], William B. Pereira[1], Renan L. Souza[1], João C. D. Lima[1], Alencar Machado[1], Eduardo C. Stabel[2] and Cristiano C. da Rocha[3]

[1]*Informatics Graduation Program, Federal University of Santa Maria, Santa Maria, RS, Brazil*

[2]*Polytechnic School, Federal University of Santa Maria, RS, Brazil*

[3]*Center of Informatics and Automation of the State of Santa Catarina (CIASC), Florianópolis, SC, Brazil*

Keywords: Persuasive Computing, Persuasive Technology, Electrical Energy Saving and Mobile.

Abstract: The growing development of persuasive technologies has led to the creation of systems that help society in a variety of sectors, one in the electric power sector, where applications seek to persuade users to change behavior and save electricity. In this sense, this article seeks to present concepts and techniques of persuasion applied in systems with this objective and to present a prototype of an application that seeks to show the user a prediction about the consumption of electric energy without him acquiring intelligent sensors, only with data that he has easy access.

1 INTRODUCTION

Decades ago the scenario of persuasive technologies was very different from what is seen today. The internet could not be accessed from anywhere and computers were designed primarily for information manipulation, calculations, storage and retrieval of data, however, according to the advances in technology, computers have migrated to people's daily lives, and have become more persuasive by design (Fogg, 2003). Today, persuasive technologies are almost ubiquitous, because of access to the internet anywhere, computers and systems are taking on the role of persuaders, which motivate and influence users which facilitates behavior change (Fogg, 2003; Oinas-Kukkonen and Harjumaa, 2009). This change in human behavior can take place in a variety of areas, such as health-related e-health applications, social networking sites, netflix integrated tv applications which sugest programs and even applications that will monitor and will suggest savings.

Studies on energy-saving systems using persuasive technologies have gradually increased, some of which suggest that persuasive technology, if applied in an environment where people are not consciously aware, may have an influence on their attitudes, and could (under certain conditions) be comparable to the influence where he would have focused attention (Ham, Midden and Beute, 2009). This approach becomes feasible to induce behavioral changes through systems that provide, for example, real-time feedback to users (Chen, 2012). In this sense, this work seeks to present the definitions of the area of persuasive technology as well as to emphasize some principles of persuasion. From the study of each technique was created the first version of an application that presents an estimate on the electric energy bill.

The article is divided as follows: section 2, the essential concepts for the understanding of the work are presented. In section 3, a study of related articles. In section 4 the prototype of the application is presented and finally in section 5, the final considerations and the future works are presented.

2 CONCEPTUAL REFERENCE

2.1 Persuasion and Persuasive Technology

Cialdini (2001) defines persuasion as the ability to induce beliefs and values in other people, thus influencing their thoughts or actions. But for persuasion to be applied, according to the author, it is necessary to define specific strategies, with the

Schiefelbein, U., Pereira, W., Souza, R., Lima, J., Machado, A., Stabel, E. and Rocha, C.
A Study on Persuasive Applications for Electric Energy Saving.
DOI: 10.5220/0006788701900197
In *Proceedings of the 20th International Conference on Enterprise Information Systems (ICEIS 2018)*, pages 190-197
ISBN: 978-989-758-298-1

focus of inducing people to adopt different behaviors.

These strategies of persuasion are commonly used by professionals in the field of marketing and web design and are divided into six main strategies according to Cialdini (2007): 1) Reciprocity: giving and receiving, the persuaded person gets the feeling of debt with the persuader 2) Commitment: people face pressures to behave in a manner consistent with their commitment; 3) Social Approval: seeking other people's approval opinions; 4) Affection: people are more influenced by those who have more affinity; 5) Authority: people with more authority have greater potential to influence; 6) Shortage: everything becomes more valuable when it is rare or limited.

Fogg (2003) seeks to explain how persuasion can be achieved through computational technologies, the author defines persuasive technology as an interactive computing system designed to change people's attitudes or behaviors, but this process is not limited to sending unilaterally a message to influence the user, but allows the sending of useful information that can support the development of a habit or position of users.

According to Spagnolli, Chittaro and Gamberini (2016), persuasive technology exploits information that technology can offer to create a user context, thus facilitating the adoption of a particular action or position.

For Oinas-Kukkonen (2010) behavior change support systems are the key to research in the area of persuasive technology, these systems are designed to shape, change or reinforce attitudes, behaviors or acts without the use of deception, thus persuasion depends on the voluntary participation of the user so that he can be persuaded.

The present work will mainly use the definitions of Fogg (2003) and Oinas-Kukkonen and Harjuma (2009) on persuasion and persuasive technologies.

2.2 Fogg Behavioral Model

From the point that persuasive technology focuses on behavior change Fogg (2009), he created a behavior model, abbreviated by FBM, where he states that in order to achieve a target behavior a person needs three factors to be performed: motivated, 2- having the ability to perform certain behavior and 3- being activated to perform the behavior, so-called triggers. From the model the functional triad was elaborated.

2.3 The Functional Triad

The functional triad, elaborated by Fogg (2003), is a conceptual framework that illustrates the different roles that computational technologies can play in persuading users. The functional triad shows that technologies can function in three basic ways: as tools, with the media, and as social actors.

According to the use of computer technology, users will be persuaded in different ways, depending on the elements that will be used.

1. The use of technology as a tool seeks to increase people's ability to perform a target behavior. The main objective is to make the activities easier or more efficient.
2. Using technology as a medium, it can be divided into symbolic and sensorial, being symbolic when computer technology transmits information about texts, graphics, etc and being sensorial means when providing information such as audio, video, smells and sensations.
3. Use of technology as a social actor, through the personification of the computer, creating a relationship as if it were a person.

For each of the elements of the triad, Fogg (2003) defined some principles of persuasion, as Table 1, which are:

Table 1: Persuasive Principles of Fogg (2003).

Tool	Media	Social Actor
Reduction	Cause and Effect	Attractiveness
Tunneling	Rehearsal	Similarity
Tailoring	Virtual Rewards	Praise
Suggestion	Simulation in Real-World Contex	Reciprocity
Self-Monitoring		Authority
Surveillance		
Conditioning		

Computational technology as a tool:

- Reduction: Reduce complex activities for simple tasks.
- Tunneling: Guide the user through sequences of events or steps, seeking to persuade him along the way.
- Tailoring: Adapt the information that will be presented according to the interest of the clients and personalized information.
- Suggestion: Provide users with the right suggestions at the right time.

- Self-Monitoring: People can achieve their goals or predetermined outcomes more easily if they feel they are being monitored.
- Surveillance: Monitor a user's behavior so that it achieves the expected result.
- Conditioning: Use positive reinforcement to change existing behavior's into new habits through rewards.

Computational technology as media:

- Cause and effect: This principle allows to observe the consequences of the real world in a safe environment, it is possible to follow the cause and effect in relation to the behaviors.
- Virtual rehearsal: It consists of a simulated environment where users can rehearse behavior that can allow a change in the real world, also serves to explore new behaviors and perspectives.
- Virtual Rewards: Offering virtual rewards for real activities.
- Simulation in Real World Context: Simulate some behavior in the context to which the user belongs.

Computational technology as actors:

- Attractiveness: More attractive software or hardware will have persuasive power greater than others.
- Similarity: Products that match user personality tend to be more persuasive.
- Praise: Praising and rewarding users make them closer to being persuaded.
- Reciprocity: When some computer system does some favour to the user he usually feels the need to reciprocate.
- Authority: The credibility that the system passes to the user influences its behavior.

2.4 Persuasive Systems Design Model (PSD)

Oinas-Kukkonen and Harjumaa (2009) created a model to assist in the development and evaluation of persuasive systems, the persuasive systems design model (PSD) and their definitions were based on the principles of the functional triad of Fogg (2003). According to him, the development of persuasive systems consists of three steps, first it is necessary to understand the fundamental issues behind the persuasive systems before implementing the system, second, to analyse the context, to recognize the intention and the events and strategies for the use of a persuasive system and third the definition of the real qualities of the system, for each stage the authors defined points that must be followed.

The three-step process for the development of persuasive systems is presented in Figure 3.

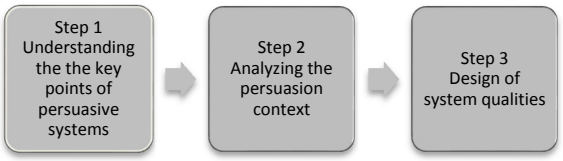

Figure 1: Steps of the development of persuasive systems.

In the first step the understanding of the key problems of the persuasive systems is made, Oinas-Kukkonen and Harjumaa (2009) defined seven postulates that help in this stage of understanding the system. These seven postulates need to be addressed to design or evaluate persuasive systems. The first two postulates relate to users in general, the other two refer to persuasion strategies and the last three refer to the real features of the system. Being them:

1. Information technology is never neutral, people are always under someone's influence.
2. People like to make a commitment to a particular situation and act with consistency.
3. Direct and indirect routes are the key to persuasion strategies where the direct route can be the person who carefully evaluates the content of the message and routes indirectly where the individual is less thoughtful and uses simple clues or stereotypes to evaluate the information.
4. Persuasion is often incremental, where it gradually increases behavior.
5. Persuasion through persuasive systems must always be open and clear.
6. Persuasive systems should be discreet to users.
7. Persuasive systems should be useful and easy to use.

In the second stage, the analysis of the context of persuasion occurs, because according to the author, without carefully analysing the context of persuasion, it will be difficult or even impossible to recognize inconsistencies in a user's thinking, to discern opportune or inopportune moments to send messages and persuade him with efficiency. This context analysis includes recognizing the intent of persuasion, understanding the persuasion event, and defining and / or recognizing the strategies in use, where:

1. Intent: Recognition of the intent of persuasion serves to determine its purpose and to define who the persuader will be.
2. Event: Understanding the persuasion event, seek to identify in the context of the user particularities and useful information for the system that will be created.
3. Strategy: The central resource to define persuasion strategies is to analyze the message, since persuasion depends mainly on strategies that trigger emotions and another central question is to consider suitable routes to be used to reach the user (direct or indirect route).

And in the third step, the model suggests the analysis of the qualities of the system where 28 design principles are proposed for the content of persuasive systems divided into 4 categories: primary task support, dialog support, system credibility support and social support.

In Table 2 the twenty eight design principles divided into four categories according to Oinas-Kukkonen and Harjumaa (2009) are presented, the principles marked with * are similar to the principles of Fogg (2003) which are detailed in Table 2, therefore only the different principles of Fogg will be described in this section.

Table 2: Persuasive Principles of Oinas-Kukkonen and Harjumaa (2009).

Primary task	Dialogue	System Credibility	Social
Reduction*	Praise*	Trustworthiness	Social learning
Tunneling*	Rewards*	Expertise	Social comparison
Tailoring*	Reminders	Surface credibility	Normative influence
Personalization	Suggestion*	Real-world feel*	Social facilitation
Self-monitoring*	Similarity*	Authority	Cooperation
Simulation	Liking*	Third-party endorsements	Recognition
Rehearsal*	Social role	Verifiability	Competition

Primary task, the design principles in this category support the accomplishment of the main tasks of the user:

- Personalization: personalized services have greater persuasiveness.

Dialogue support, design principles in this category are provided primarily through system feedbacks to the users:

- Reminders: If the system reminds the user of their target behavior they are more likely to achieve their goal.
- Social Role: if the system adopts some social role users will use this for persuasive purposes.

Supporting credibility, the design principles in this category describe how to design a system to make it more reliable and therefore more persuasive:

- Reliability: A system that is seen as reliable will have greater power of persuasion.
- Knowledge: The system that shows knowledge, experience and competence has more power of persuasion.
- Credibility: People make initial assessments of the credibility of the system based on the first visit.
- Endorsements: Third party endorsements, especially from well-known and respected sources, increase perceptions about the credibility of the system.
- Verifiability: Perceptions of credibility will be enhanced if a system makes it easier to verify the accuracy of website content through external sources.

Social Support, the principles in this category describe how to design the system so that it motivates users by leveraging social influence.

- Social learning: A person will be more motivated to perform a target behavior if he or she uses a system to observe others who perform the behavior.
- Social Comparison: System users will have a greater motivation to perform target behavior if they can compare their performance to the performance of others.
- Normative Influence: A system can use normative influence or peer pressure to increase a person's likelihood of adopting a target behavior.
- Social Facilitator: The system should provide the means to discern other users who are performing the behavior.
- Cooperation: The system should provide means for cooperation.
- Competition: The system must provide means to compete with other users.
- Recognition: By offering public recognition to an individual or group, a system can increase the likelihood of a person / group engaging in target behavior.

2.5 Differences between the Principles Described in the Model of Fogg (2003) and Oinas-Kukkonen (2009)

From the principles marked with * in Table 2 it can be seen that ten of the twenty-eight principles of Oinas-Kukkonen and Harjumaa (2009) are similar to those of Fogg (2003), but in Oinas-Kukkonen (2009) is different..

As for example, the suggestion principle, which in Fogg's model is classified as being a tool that will help the user to reach his goal, already for Oinas-Kukkonen and Harjumaa he is classified in the category of dialogue support, since the main benefit of the suggestion is meaningful content for the user and does not make the suggestion support the completion of a process.

The principles related to Oinas-Kukkonen's and Harjumaa's dialogue support resemble the social actors of Fogg (attractiveness, resemblance and praise) and media (the virtual rewards). Reminders and the social role are new principles proposed by the authors. Reciprocity is not in the frame because according to the author it is a characteristic of a user and not a system resource.

Design principles in the social support category were adopted by Fogg's principles on mobility and connectivity. The opportune and inopportune moment and the ideas behind the quality of information, convenience and simplicity were addressed in the postulates in other categories.

The principles of vigilance and conditioning are not addressed by Oinas-Kukkonen and Harjumaa, because for authors, often people can not choose whether they can be observed or not.

Fogg (2003) seeks in his studies mainly to define in what ways computational technologies can act as persuasive technologies, studying how users react and use these technologies.

And Oinas-Kukkonen and Harjumaa (2009) developed in their studies methods to develop systems with persuasive requirements and methods to evaluate these systems.

2.6 Energy Saving

The reduction of expenses with electricity consumption has become one of the main objectives in both the residential and industrial sectors. In the residential sector, the spending on energy consumption is increasing. In 2007, according to National Electric Energy Agency, in Brazil, the consumption of the residential sector was only below the transport and industrial sector in the percentage on the total energy consumption (ANEEL, 2005). In the United States, household energy use accounts for more than 20% of total CO2 emissions, (Dietz et al, 2009), these data have attracted interest in the development of applications to provide residential economy.

One of the major problems of residential consumers, according to Darby (2006), is the lack of transparency on the expenditures of electricity consumption, since most of the time the consumer will only know the amount of energy consumed at the end of the month of the light bill. The author points out as a possible solution to this case, the availability of direct and indirect feedback through systems and applications on the consumption in the residences, because from this information he can change his behavior and as a consequence he achieves the reduction of expenses.

Many of the users who seek energy savings are already aware that they need to adopt a new behavior and only need an encouragement, a trigger, that can be delivered through ICTs - Information and Communication Technologies (Vilarinho et al, 2016). The application of persuasive computing to improve energy consumption habits in households is a good case because small changes in the behavior of energy consumption can result in substantial impact (Winett, 2013).

In this sense, research that approaches persuasive concepts that help users with sustainable practices has been approached by Shevchuk and Oinas-Kukkonen (2016), where the authors call Green IS and Green IT, green information systems or green information technology. Their research explores persuasive principles used in green IT applications designed to implement long-term changes in users' behaviors.

In order to better understand how applications using persuasive techniques generate changes in human behavior and subsequently energy savings, the next section presents works with this bias.

3 RELATED WORK

In this section of related works we searched for articles that use persuasive techniques to obtain behavioral changes and that subsequently caused electric energy savings. Six articles were selected and from them a verification of the techniques used in each one of them was carried out and the results were presented in a comparative table, which appears at the end of this section.
Caption in the table:

Article (1) refers to the article of Vilarinho et al. (2016); Article (2) refers to the article of Zapico, Turpeinen and Brandt (2009) ; Article (3) refers to the article of Chen et al (2012); Article (4) refers to the article of Sundramoorthy et al. (2011); Article (5) refers to the article of Petersen, D., Steele, J., & Wilkerson, J. (2009); Article (6) refers to the article of Casado-Mansilla et al. (2016).

Table 3: Comparison of related works.

Principles	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Reduction		x				x
Tunneling						
Tailoring						
Personalization						
Self-monitoring	x	x	x	x	x	x
Simulation	x	x	x	x	x	x
Rehearsal	x		x	x		
Praise						
Rewards	x		x			
Reminders	x			x		
Suggestion	x		x	x		x
Similarity						x
Liking	x		x		x	x
Social role			x			x
Trustworthiness						
Expertise						
Surface Credibility						
Real-world feel	x	x	x	x	x	x
Authority						x
Third-party endorsements						
Verifiability						
Social learning	x		x	x		x
Social comparison	x	x	x	x	x	x
Normative influence	x		x	x		x
Social facilitation	x		x	x		x
Cooperation			x			x
Recognition	x		x		x	x
Competition						
Surveillance	x		x			x
Conditioning						

From the analysis of Table 2, it can be seen that all the works used the principle of self-monitoring, simulation and social comparison. Self-monitoring and simulation are common features in power management systems, and this becomes clear in the definitions of these principles, where self-monitoring defines that users perceiving that they are being monitored tend to change the behavior and simulation that allows users to know consequences of their attitudes.

The use of the principle of social comparison shows the influence on motivation of users, because when they can show and compare their performance with other people they tend to change their behavior, this has been growing in the most varied domains of applications mainly with the use of social networks .

Other principles that have often appeared were the principles of suggestion, appearance, social learning, normative influence, recognition.

4 PERSUASIVE MOBILE ENERGY SAVING APPLICATION

Based on the principles studied on the development of persuasive systems, this article proposes a first version of an application focused on the management of electric energy. Based on daily data, inserted by the user, in relation to his perception of the time used of the equipment that has cataloged on the platform by the user, it is sought to project, by means of mathematical formulas, the consumption at the end of the month. The application uses, in its interaction with the user, some of the principles of persuasion that will be explained shortly.

The article sought to develop an application that does not cause the user to spend money on the purchase of hardware, such as sensors or specific devices, but to have an estimated projection of your account with all the information available on your account.

Step 2: Analyze the context by identifying: **Intention of persuasion:** to raise awareness about the saving of electric energy, and to promote changes in behavior. **Event:** The user profile is summarized in a parent who seeks to have a forecast of electricity consumption without having to spend it, this user has a smartphone connected to the internet full time. **Persuasion strategy**: indirect.

Step 3: Using persuasive principles to present information, the application uses six of them:

Simulation, suggestion, appearance, self-monitoring, personalization, rewards.

The application needs the following data: information on consumption history in the previous months (data included in the monthly bills of light); information about the user profile; and the power of equipment that consumes electricity (it can delete and add new ones at any time). This quoted data is entered only once when the application is installed. To provide a projection requires a daily record of the use time of each equipment, however the main data are referring to the consumption of the electric shower, air conditioning and electric oven, if they exist. The time of the other equipment if the user did not want to enter every day, will be copied the last supply.

From this data set, it is sought to estimate the daily consumption of electricity (in kWh), in addition to the projection for monthly consumption and the amount to be paid, taking into account the tariff flag in force in that month. For this, some formulas of physics and mathematics are used. Below is explained how the estimated daily consumption and the projection at the end of the month are calculated.

According to the data insertion, we have a number n (total) of equipment inserted in the application. A certain index i ranges from 1 to n, corresponding to the first, second, ... equipment. Each day, the user enters the time of use of each equipment in the variable time (i) (will be transformed into hours). The formula of the energy consumed is given by the expression power (i) x time (i), then we have the consumption of the equipment in the day. After calculating the consumption of each equipment, they are all summed up and have the consumption of the day stored in the variable consumptionEstimate (day), where day is the day in question. These values are calculated, summed and stored every day.

The projection for 30 days, in this first prototype is realized by the rule of three.

$$monthlyProjection = \frac{30}{day} x\ consumptionEstimate(day). \quad (1)$$

This variable is estimated to have the unit of measure kWh (the same as the light count). In order to calculate the value of the account (in monetary value), it is necessary to multiply the tariff flag in force in the month and the tariff. Figure 1 shows the screen where the user informs the time of use of each equipment and in Figure 2, the consumption projection for a given month.

Figure 2: Screen of the application where the user informs the time of use of each equipment.

Figure 3: Application screen where the projection of consumption, comparison and notification is presented.

When presenting to the user the value of the projection of the light account the application makes the comparison with the value of the same month of the previous year, if the current value is less than last year it calculates the difference and presents a message of congratulation. Then at the end of the month when the actual account arrives it will register that new value and whenever there are real energy savings in relation to the consumption, these values will be stored and summed. With this, the user can track how much he has already saved compared to the previous year.

To stimulate the provision of data on the platform the user indicates the best time of day he would like to receive a reminder, so at this time he

will receive a notification reminding of the importance of providing data, which will give a more accurate estimate.

5 CONCLUSIONS

The article presented only the prototype of the application that uses persuasive computing principles to seek to change user behavior with the focus on saving electricity. The main idea was to show that only with information that is easy to access is it possible to have a prediction of consumption, even if it is estimated, this domain of research allows the use of several tools to predict. These will be developed in the future works, where in the next version of the application the user will not need to inform several information regarding the energy consumption, because a neural network will be implanted and from consumption history, number of people in the house and average temperature of the city will be possible to predict consumption in the coming months, providing more assertive data for the tests. This information will be presented so that the user can graphically compare whether their consumption has increased or decreased. From this neural network it will be possible to identify correlations between the information and identify the consumption profile of certain groups and thus through persuasive computation to seek changes in behavior in order to achieve savings of electric energy.

ACKNOWLEDGEMENTS

The authors would like to thank CAPES for partial funding of this research and the UFSM/FATEC through project number 041250 - 9.07.0025 (100548).

REFERENCES

Fogg. B. J.. 2003. Persuasive Technology: Using Computers to Change What We Think and Do. *San Francisco: Morgan Kaufmann Publishers.*

Fogg, B. J. 2009. Creating persuasive technologies: an eight-step design process. In *PERSUASIVE (p. 44).*

Ham, J., Midden, C., & Beute, F. 2009. Can ambient persuasive technology persuade unconsciously?: using subliminal feedback to influence energy consumption ratings of household appliances. In *Proceedings of the 4th International Conference on Persuasive Technology (p. 29). ACM.*

Chen, H. M., Lin, C. W., Hsieh, S. H., Chao, H. F., Chen, C. S., Shiu, R. S., ... & Deng, Y. C. 2012. Persuasive feedback model for inducing energy conservation behaviors of building users based on interaction with a virtual object. *Energy and Buildings, 45, 106-115.*

R. B. Cialdini. Influence: science and practice. *4th ed., 2001.*

Cialdini, R.B. 2007. Influence: The Psychology of Persuasion, *revised edition. HarperCollins.*

Oinas-Kukkonen, H. & Harjumaa, M., 2009. Persuasive systems design: Key issues, process model, and system features. *Communications of the Association for Information Systems, 24(1), p.28.*

Spagnolli, A., Chittaro, L., & Gamberini, L. (2016). Interactive persuasive systems: a perspective on theory and evaluation. *International Journal of Human-Computer Interaction, 32(3), 177-189.*

Oinas-Kukkonen, H. 2010. Behavior change support systems: A research model and agenda. *Persuasive technology, 4-14.*

Fogg, B. J. 2009. A behavior model for persuasive design. In *Proceedings of the 4th international Conference on Persuasive Technology (p. 40). ACM.*

ANEEL - Agência Nacional de Energia Elétrica. 2005. Atlas de Energia Elétrica do Brasil. Disponível em: http://www.aneel.gov.br/. Accessed in: 05/12/2017.

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. 2009. Household actions can provide a behavioral wedge to rapidly reduce U.S. carbon emissions. *Proceedings of the National Academy of Sciences of the United States of America, 106, 18452-18456.* doi:10.1073/pnas.0908738106

Darby, S. 2006. The effectiveness of feedback on energy consumption. A Review for DEFRA of the Literature on Metering, Billing and direct Displays, 486.

Vilarinho, T., Farshchian, B., Wienhofen, L. W., Franang, T., & Gulbrandsen, H. (2016). Combining Persuasive Computing and User Centered Design into an Energy Awareness System for Smart Houses. In *Intelligent Environments (IE), 12th International Conference on (pp. 32-39). IEEE.*

Winett, R. A. 2013. Information and behavior: Systems of influence. *Routledge.*

Zapico, J. L., Turpeinen, M., & Brandt, N. (2009). Climate persuasive services: changing behavior towards low-carbon lifestyles. In *Proceedings of the 4th International Conference on Persuasive Technology (p. 14). ACM.*

Chen, H. M., Lin, C. W., Hsieh, S. H., Chao, H. F., Chen, C. S., Shiu, R. S., ... & Deng, Y. C. 2012. Persuasive feedback model for inducing energy conservation behaviors of building users based on interaction with a virtual object. *Energy and Buildings, 45, 106-115.*

Sundramoorthy, V., Cooper, G., Linge, N., & Liu, Q. 2011. Domesticating energy-monitoring systems: Challenges and design concerns. *IEEE pervasive Computing, 10(1), 20-27.*

Petersen, D., Steele, J., & Wilkerson, J. (2009, April). WattBot: a residential electricity monitoring and feedback system. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems (pp. 2847-2852). ACM.*

Casado-Mansilla, D., López-de-Armentia, J., Ventura, D., Garaizar, P., & López-de-Ipina, D. 2016. Embedding intelligent eco-aware systems within everyday things to increase people's energy awareness. *Soft Computing, 20(5), 1695-1711.*