

# The Use of Persuasive Strategies in Systems to Achieve Sustainability in the Fields of Energy and Water: A Systematic Review

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**Keywords:** Persuasive Technology, Sustainability, Energy, Water and Systematic Review.

**Abstract:** The use of persuasive applications to change behavior has presented efficient results in the most varied areas, for example in the health area, applications send notifications remembering daily exercises and in addition to losing calories you can still accumulate points. In the domains that involve sustainability linked to the use of electric energy and water the persuasive applications have shown promise and present a good field to follow. In this sense this work presents an investigation about which persuasive strategies are most used and which can still be explored in the applications that seek to make the user have a sustainable behavior in the use of water and electricity. This research has taken place through a systematic review.

## 1 INTRODUCTION

Convincing the user through applications to perform attitudes different from what he usually does has proved to be an effective solution to some problems, such as helping to lose weight, perform more physical activities, or even help to have more sustainable attitudes. To lose weight, for example, encouraging messages in addition to calorie-losing charts can be very persuasive.

Calls persuasive applications come precisely for this purpose, providing changes in user behavior so that attitudes occur naturally and may even become a new habit.

Concern for the environment has been highlighted lately, both large companies and at home simple locals, this happens because of scarcity of natural resources, accompanied by a large volume of waste generated every day, in addition to high rates related to the consumption of electricity and water.

In order to investigate works that create applications that use persuasion to promote sustainable behavior in relation to the use of electricity and water, this article presents a systematic review.

According to (Kitchenham and Charters, 2007) a systematic literature review is a means of identifying,

evaluating and interpreting all available research relevant to a particular research question. In this sense, the present systematic review investigates the use of persuasive principles in systems that seek to promote sustainability in the domains of energy and water in domestic environments.

The process guidelines for systematic review according to (Kitchenham and Charters, 2007) cover three phases of a systematic literature review: planning the review, conducting it and reporting it, where the planning phase mainly involves the identification stages of the need for review and specification of the research questions, the conduction phase of the review mainly involves the stages of selection of the search string, selection of the database and selection of articles by means of the inclusion and exclusion criteria and finally the phase of the review report mainly covers the stages of analysis of the work in order to develop the final report of the systematic review.

In this way the article is organized as follows: section 2 the background that has some concepts necessary for the understanding of the work. In section 3 the systematic review and its steps and in section 4 the conclusion.

## 2 BACKGROUND

### 2.1 Persuasive Technology

The study of persuasive technologies arises with (Fogg 2003), where research was directed at figuring out how computing can help achieve persuasion.

The author, who is one of the first to use persuasive technologies in computational research, defines the technologies provided by persuasive computing as interactive computing systems, designed to change attitudes or behaviors, he emphasizes that this process is not limited to sending messages to influence users, but rather makes it possible to send useful information that can somehow support the development of a new habit or positioning. Fogg (2003) has established 16 persuasive principles that if used in computer applications increase the chances of persuading the user, these 16 principles or persuasive strategies are divided into 3 categories, tool, media or social actor, which form the functional triad of Fogg.

Other authors have also devoted their research to persuasive technologies (Oinas-Kukkonen and Harjumaa, 2009), for example, define persuasive systems as software or information systems designed to reinforce, change attitudes or behaviors. It is emphasized by (Fogg, 2003) and (Oinas-Kukkonen and Harjumaa, 2009) that persuasion can not occur through coercion or deception. Oinas-Kukkonen and Harjumaa (2009) defined 32 persuasive strategies that are part of their persuasive application design model, the abbreviated PSD.

### 2.2 The Application of Persuasive Technology

The increasing use of mobile devices has favored the application of persuasion in web pages and applications. Fogg (2009) cites some other advantages of using the so-called mobile computing: persistence, where it is possible to inform the user countless times (automatically) about a given situation, anonymity, it is possible to get where the human being cannot go or not is welcome and lastly the author cites scalability, where it is possible to manage a large volume of data.

Currently different areas are using persuasion to change users' habits, most often messages are sent that remind or alert a certain behavior. A study by (Matthews et al., 2016) in the form of a systematic review, presented an analysis of some of the major works that present mobile applications that promote physical activities. Applications that use persuasion

for this purpose usually monitor physical activities performed and send messages about their performance, as well as personalized notification of encouragement to physical activities. As conclusion of this study (Matthews et al., 2016) realized that the self-monitoring strategy was the most used by the applications, as well as support for the dialogue for feedback and social support strategies.

Domains within smart cities are also being tested, the recent study (Anagnostopoulou et al., 2017) shows several papers that have used applications with persuasive technologies for sustainable urban mobility. The applications send messages with alternate routes, transit and time information, as well as messages that allow the user to cycle through when possible or walk to certain places.

In addition to the areas cited, numerous others are increasing their research on the use of persuasion for behavior change, areas such as education, conscious consumption and areas related to sustainability. In the section below will be presented a systematic review that presents some of the main works found in the literature that have developed persuasive applications for change in the behavior in relation to the use of electric energy and water.

## 3 SYSTEMATIC REVIEW

### 3.1 Planning

In order to identify existing solutions around how persuasive technology is applied in environments that seek sustainability and in the same way to identify the least used strategies in this context, the following research question:

Q1 - What are the most and least persuasive principles used in systems that aim at sustainability in the domains of energy and water use in domestic environments?

Q2 - What particularities do sustainability persuasion systems have?

### 3.2 Conducting the Systematic Review

Elaboration of the search string: For the definition of the search strings the words persuasive computing and persuasive technology were used, between the strings the boolean operator OR was used because the words technology or persuasive computing have the same meaning. As the research question aims to answer sustainability issues involving water or energy, these words were also separated by the Boolean operator OR, so the research could be

broader. The search string is limited to titles, abstracts and keywords, so use the TITLE-ABS-KEY sentence. In this way the search string created is represented in Figure 1.

TITLE-ABS-KEY ("persuasive computing" OR "persuasive technology") AND TITLE-ABS-KEY ("sustainability") OR ("energy") OR ("water")

Figure 1: Search string.

Definition of the database: the search was performed in the online database Scopus Elsevier, considered one of the largest databases of peer-reviewed literature.

Inclusion and exclusion criteria: inclusion criteria aim to direct the selection of articles that will answer the research question and, on the other hand, the exclusion criteria serve to retain articles that will not be useful at this time of the research. The inclusion criteria are represented by (I) and the exclusion criteria by (E), as presented in Table 1.

Table 1: Inclusion and exclusion criteria.

Inclusion	Exclusion
(I-1) Studies that contain terms of computing or persuasive technology and sustainability issues in the title, abstract or key words.	(E-1) Studies that were not in the area of computer science.
(I-2) Studies that have implemented or designed systems that use persuasive principles to achieve sustainability.	(E-2) Studies that did not contain terms of computing or persuasive technology and sustainability issues related to energy or water in the title, abstract or keywords.
(I-3) Studies that have been designed for domestic environments.	(E-3) Studies that addressed only concepts and techniques and did not develop some application or that demonstrated the applicability of persuasive principles in the sustainable environment.
	(E-4) Studies involving persuasive systems geared toward sustainability have however been tested or designed for workplaces, public squares, schools.

Extraction of works: The query in the database was made in July 2018. Figure 2 represents the steps for selecting the articles that were analyzed.

In the first stage, 324 articles were identified, after the exclusion criterion (E-1) was applied, which excludes non-computer science works. Then, the exclusion criterion (E-2) was applied where the titles, key words and abstracts were verified if the works contained computing or persuasive technology terms and sustainability issues related to water or energy, leaving 113 articles. After an analysis of the 113 articles, the exclusion criterion (E-3) was applied, where articles that did not implement any application or that demonstrated the applicability of persuasive principles in the sustainable environment were excluded, in this way the inclusion criterion (I-3) was satisfied, the exclusion criterion (E-4) that excluded articles that were designed or tested in public settings such as squares, schools or work environments was still applied. In this way, inclusion criteria (I-3) were included, where only articles that were designed for domestic environments were included. After reading each one, 12 articles were still excluded, remaining 11 for review use.

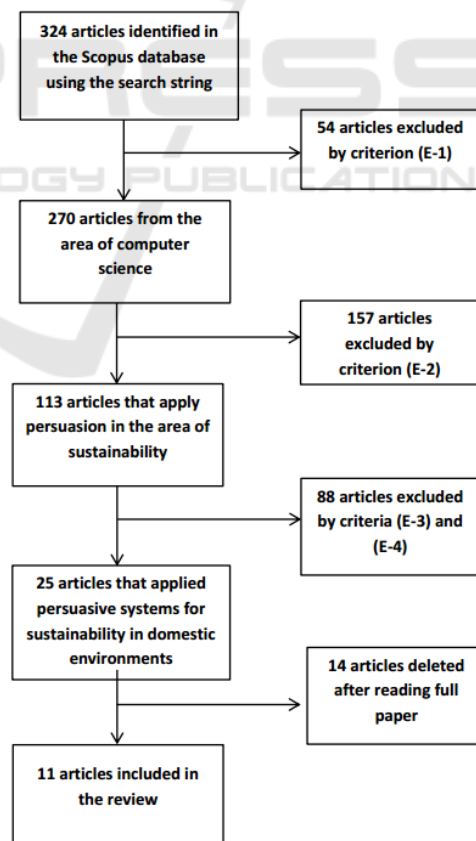


Figure 2: Articles Selection Steps.

### 3.3 Report of the Review Results

#### 3.3.1 Selected Works

**Article 1 [A1]-** In the work of (Foster, Lawson and Blythe, 2010) occurred the deployment and evaluation of the web system called Wattsup. To create the system the end users themselves expressed their opinions and ideas of what elements the system could have. The system is integrated into the social network Facebook, it shows data of energy consumption and data related to CO<sub>2</sub> release. In addition, charts, rankings and comparisons between friends can be generated.

For the system test 8 houses were selected, totaling 20 people. Participants were divided into 2 groups A and B, in the first moment the participants of group A besides seeing the data of the own consumption could see the data of the consumption of friends in Facebook and the participants of group B only had access to the own data. The experiment lasted 18 days and the results showed that participants who could compare their data with friends on the social network were more motivated to use the system and in addition they managed to save about 130kwh. To evaluate the work, the authors used questionnaires to find out what influence the system caused in them.

**Article 2 [A2]-** In the work of (Petersen, Steele and Wilkerson 2009) a mobile application called WattBot was developed with the purpose of monitoring and providing a feedback on domestic consumption. For design definition a group of local university working with sustainability has helped. The application shows the consumption of each device in the house in the form of a ranking, the appliance that consumes more energy is at the top of the list in red and as the consumption is less the colors are lighter (orange, yellow and green).

The tests mainly occurred to evaluate the design of the application interface, the number of testers and the time that was used was not identified at work.

Participants were able to navigate the application and liked the way the power consumption was arranged, but they would like to be able to compare consumption with data from past consumption.

**Article 3 [A3]-** In the work of (Gamberini et al., 2012) a game for web called EnergyLife was developed, the game shows in letters form the individual consumption of each domestic appliance that consumes energy.

As the participant is saving energy he goes up the level. At the first level he can only see the current

situation and the last week, then he starts to receive saving tips, besides receiving questions that can add up points. At the last level he can share his results with other people.

The tests occurred for 4 months with 10 participants. Interviews were done at the beginning and at the end of the experiment to evaluate the participant's progress. The final results indicated savings of approximately 33% in some equipment, in addition to increasing the participant's awareness.

**Article 4 [A4]-** In the work of (Petkov et al., 2011) a mobile application called EnergyWiz was developed, it mainly uses social comparison resources. The application shows real-time consumption, history, challenges, ranking and comparisons between neighbors. For design creation (Petkov et al., 2011) were based on theory-oriented design (Card, 1998). Tests were performed with 17 participants for 1 week. One of the features of the app was choosing a friend and keeping track of his friend for a week. In this way the user was committed and above all motivated to save energy. For the evaluation the answers of the questionnaires were analyzed.

**Article 5 [A5]-** In the work of (Sundramoorthy et al., 2011) was developed a web system called Dehems it serves for home energy management. To create the design, elements described by (Fitzpatrick and Smith 2009) were used. First a prototype was developed and then the final system. The tests happened in 250 houses the duration of the tests took 4 months.

Users could track their consumption and also compare them to neighbors. The system shows the amount of gas and energy expended, in addition to CO<sub>2</sub> emission and monetary values. The participants found it very clear how information is presented, so they were always reflecting on their actions.

For evaluation, comparisons were made with the data related to the energy and gas consumption of the months prior to the experiment and interviews were also conducted where they reported on their sustainable activities. The results showed that it is possible to have a significant reduction in energy use through persuasive applications, but to prove that there has been an improvement in environmental awareness has not yet been possible, because often the reduction in consumption happens because of monetary values.

**Article 6 [A6]-** In the work of (Takayama et al., 2009) EcoIsland was developed, a web system to reduce CO<sub>2</sub> emissions. EcoIsland is a game designed for



daily activities for a family that has an interest in behaving in a more ecological way.

The family defines a target CO<sub>2</sub> emission level and the system tracks its current approximate emissions using sensors. If the emission reaches the target level, the water around the island increases and at the end of the game.

The tests happened with 6 voluntary families, for a total of 20 people. Families used the system for 4 weeks. At the end of the project evaluation, a questionnaire was applied.

The results showed that 17 of the 20 participants were more aware of environmental issues after the experiment. 16 participants reported that they acquired new knowledge about the subject. But participants reported that often the motivation to maintain sustainable habits was for reasons of the game, such as not letting the island sink or increase points and not for an improvement in the environment.

**Article 7 [A7]-** In the work of (Røsok 2014) it was explored how smart energy meters can be combined with social media. The concept involves the use of collaborative group competition, where consumers can join groups and compete with others in energy savings, and can win prizes. The goal is to raise awareness of energy as well as global awareness.

For the design of the prototype were interviewed some families to collect elements that they found important for motivation.

In the system it is possible to compare individual consumption with the group, in the current day and week or last month, the tests happened with 4 adults. The results showed that the techniques used have great potential to motivate consumers to use less energy. Competition among individuals proved to be very attractive to most participants, describing it as the main motivational factor. In the project some experts evaluated the interface and the end users evaluated the usability and in both the result was well satisfactory.

**Article 8 [A8]-** In the work of (Perren et al., 2016) the authors created a mobile application and a web page that serves as support for decisions of domestic water consumption. The project came up to take advantage of existing environmental standards to promote water saving, the main purpose of the work was to test the efficiency of using different sources of information during persuasion.

Information about domestic activities and the use of water was collected and it was on this collected information that expert tips were sent in order to make

the behavior of the user change. The tests occurred in 40 households for an unspecified time, users received tips related to day-to-day activities, each message compared information that the user had previously reported and indicated a new behavior. The results showed that the use of reliable sources.

**Article 9 [A9]-** In the work of (Paay et al., 2013) the authors discovered eight techniques that proved to be comprehensive for the persuasion of a sustainable consumption of natural resources in the fields of water and electricity saving. One system for advising the use of water has been designed and another for the reduction of electricity. The water-saving system focused on supporting gardeners by watering the garden, sending meteorological information, soil moisture data and advice from horticultural experts in order to influence gardeners to save water. In this sense the gardeners skipped a few days of watering the garden. The energy-saving system also provides information from weather experts, community councils and data on personal consumption.

The results indicated that the messages received during the use of water and energy were very well received in the sense of awakening the awareness of their energy consumption. The eight techniques that worked efficiently for both water and energy savings were: self-comparison, trigger messages, use of mobile devices, understandable messages, personalized information, community information, expert advice, and behavior change throughout time.

**Article 10 [A10]-** In the work of (Vilarinho et al., 2016) was developed a web system called CoSSMic, the concept of increasing energy consumption and becoming a concept of greener behavior. In the software was developed following the methodology of research in design science anchored by the application of User-Centered Design and theories of persuasive computing.

The development of the user interface (UI) was done after iterations with end users and expert assessment. The main strategies for behavior change addressed by the authors were, to apply social norms, feedback techniques, social cues and gamification. The tests were mainly done to evaluate how design issues can help change behavior.

The results of the evaluation of the experts showed that the use of social comparisons and gamification can stimulate the motivation for software with this objective. Feedback with suggestions can trigger concrete actions in relation to energy efficiency.

**Article 11 [A11]**- In the work of (Laschke et al., 2011), a bath schedule was developed, where the authors persuasively sought to reduce water consumption in the bath.

The system designs a screen in the bathroom stall, when a user starts his bath he tightens the play. Each user is symbolized by a large colored circle, when the bath begins the circle begins to decrease and then the size of the circle is saved on the screen. The goal is for each member of the family to try to decrease their bath more and more.

The tests were carried out with 2 families totaling 6 people for 31 days. The results were different in the two families, one had a significant reduction in water, but the other did not obtain a very significant margin. For Laschke et al., (2011) this is a common problem of persuasive technologies, since change will depend on whether the behavior change is important to the user at that time.

### 3.3.2 Comparison of Related Work

After reading and analyzing the selected articles, a Table 2 was generated with some of the particularities of each article. For the information in the table the following captions were created:

IP=Interviews with users and creation of a Prototype based on information collected with end users.

QLE=Qualitative Evaluation, analysis of interview responses. In general questions were asked about the change in system behavior and usability.

QE= Quantitative evaluation, comparison of historical data and current data on consumption, it was verified whether there was reduction of consumption and monetary expenditure.

NS= Not Specified.

From the point that some of the selected articles diverge in the manner of the use of persuasion, Table 3 shows which are the main persuasive principles used in each work was constructed.

### 3.3 Justification of the Chosen Criteria

The choice of criteria in Table 3 followed the persuasive principles also analyzed in the systematic review of Shevchuk, Oinas-Kukkonen (2016) where the authors sought to identify which of the 28 persuasive principles present in the PSD created by Oinas-Kukkonen and Harjumaa (2009) were used in systems containing "green" solutions. The systematic review of Shevchuk and Oinas-Kukkonen (2016) did not address systems that were designed using persuasion techniques.

Table 2: Special features of the selected articles.

Articles	Sustainable domain	Methodology for creating the system	Validation	Number of testers	Test time
[A1]	Energy	IP	QLE and QE	8 families, 20 people	18 days
[A2]	Energy	Assistance from a group focused on sustainability.	QLE	NS	NS
[A3]	Energy	IP	QLE and QE	4 families, 10 people	4 months
[A4]	Energy	Design oriented theory (Card 1989).	QLE	17 people	1 week
[A5]	Energy	Characteristics oriented by (Fitzpatrick and Smith 2009)	QLE and QE	250 houses, number of people not specified	4 months
[A6]	CO2	NS	QLE and QE	6 families, 20 people	4 weeks
[A7]	Energy	IP	QLE	4 people	NS
[A8]	Water	NS	QE	40 houses, number of people not specified	NS
[A9]	Water and Energy	Characteristics oriented by (Pearce et al., 2009)	QLE	10 people	3 weeks
[A10]	Energy and CO2	User-centered design	QLE	NS	NS
[A11]	Water	NS	QLE and QE	2 families, 6 people	31 days

In this sense the systematic review of the present work used as a criterion of comparison the 28 principles present in the PSD, plus 3 persuasive principles that the functional triad of (Fogg, 2003) addresses but the PSD model does not. Another criterion included was that of gamification, although it is not considered as a persuasive principle, it has techniques that directly map the implementation of different motivational and triggering theories (Vilarinho, 2016).

After analyzing each work presented in Table 3 were separated the 10 strategies or persuasive principles that are most used in sustainable persuasive systems, the list is in Table 4.

It is important to make it clear that persuasive principles or strategies that were least used are not ineffective, they simply have not been much tested. In this way these principles can still be explored to test their efficiency. Based on the identification of these principles the research question from the Systematic Review is answered.

Table 3: Persuasive principles present in each article.

Persuasive Principles / Articles	[A1]	[A2]	[A3]	[A4]	[A5]	[A6]	[A7]	[A8]	[A9]	[A10]	[A11]
Reduction											
Tunneling											
Tailoring											
Personalization								Yes		Yes	
Self-monitoring	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Simulation	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rehearsal					Yes						
Praise				Yes							
Rewards			Yes	Yes	Yes		Yes		Yes		
Reminders							Yes		Yes		
Suggestion	Yes		Yes					Yes		Yes	Yes
Similarity											
Liking	Yes	Yes		Yes	Yes		Yes			Yes	Yes
Social Role						Yes		Yes	Yes		
Trustworthiness		Yes									
Expertise			Yes					Yes	Yes	Yes	
Surface credibility									Yes		
Real world feel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	
Authority											
Warranty											
Verifiability											
Social learning	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Social Comparison	Yes		Yes	Yes	Yes	Yes	Yes			Yes	Yes
Normative influence	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Social facilitator				Yes	Yes	Yes		Yes	Yes		
Cooperation						Yes	Yes				
Competition	Yes		Yes	Yes	Yes	Yes	Yes			Yes	Yes
Recognition	Yes				Yes						
Surveillance	Yes	Yes			Yes	Yes				Yes	Yes
Conditioning								Yes			
Reciprocity											
Gamification	Yes		Yes			Yes	Yes			Yes	Yes

Table 4: Principles/Strategies most used.

Principles/Strategies most used
Self-monitoring
Simulation
Social learning
Normative influence
Real world feel
Competition
Social Comparison
Suggestions
Liking
Surveillance

## 4 CONCLUSION

The work presented a systematic review that has as main objective to show which persuasive strategies are most used in applications that seek sustainability. The research focused on investigating works that designed their systems of behavior change for residential users, that is, were analyzed persuasive systems that sought to persuade the user of common residences to use energy and water sustainably.

As a result we have found some persuasive strategies that are heavily used in systems that seek to persuade the user to sustain behaviors. We can cite 3 strategies that have appeared a lot: self-monitoring and simulation that most of the time are together, where data is usually monitored and simulations are performed that cause users to think about the consequences of their actions, and another strategy strongly used is facilitation social, where increasingly the use of communities and social networks are being incorporated into the projects, this way there is a great deal of involvement with the application and users can learn from each other. However, the use of the social network to seek savings should be used with attention according to Foster, Lawson and Blythe (2010), because to stay connected to social network is necessary to consume energy as well.

As can be seen in Table 3, there are many persuasive principles / strategies that are few explored and many have not yet been tested. Some new strategies may also arise, such as gamification, which was not actually listed as a persuasive principle by Fogg (2003) or Oinas-Kukkonen and Harjumaa (2009) but is now being included as a persuasive principle (Vilarinho 2016).

Finally, as a systematic review, it is expected that the persuasive strategies that are still little used in applications related to the sustainable use of water and electricity are more used and tested in order to find out when they can be more efficient.

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