Analysis of the Gamification Applications to Improve the Energy Savings in Residential Buildings

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Abstract: - This paper proposes a set of metrics to evaluate and compare applications in a new but quickly developing field – energy management software (EMS) in residential buildings. The goal of the paper is to highlight tendencies and to detect drawbacks of present applications to develop a new one taking into account the results of previous analysis. It shows a shortlist of applications examined. Provides the conclusion drawing to the metrics and proposes main issues to be considered in the development of a new application.

Key-Words: - gamification, building, simulation, sustainability, energy, savings.

1 Introduction

The subject of saving the energy in the meaning of saving the environment has first taken shape in 1980, w hen the term "sustainable environment" was officially mentioned by IUCN in their WCS report (IUCN report of 1980). Nevertheless, it was always more about technologies of energy production and legislation of its usage. The idea of changing the behaviour of users became more popular just in last 10 years. Moreover, the development of Energy Monitoring Systems (EMS) for domestic users was accelerated by the first trials in this field of well-known international companies about 5 years ago, which accidently had no success and had to close their projects [1] [2]. Therefore, this market is quite novel and unstructured.

2 Information quality

2.1 Relation between information and simulation

Information about the consumption of energy is necessary for precise simulation. Therefore, the more information we have the more information the simulation produces and better quality of the results is achieved, see Fig.1.
However, in the schema is missing one of the most important actors of system: the users.

The most challenging goal due to the project nature is to find the balance between game and simulation, between a user-friendly interface and the representativeness of the application in order to involve the users to provide the needed information.

Fig. 1. Relation between information and simulation

The users, as is represented on figure 2 is the glue between the information and the simulation model to be developed.

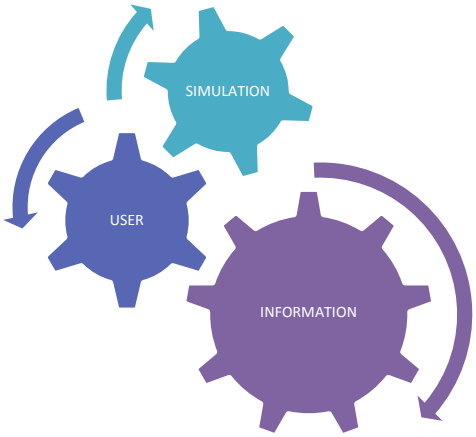

Fig. 2. Relation between user, simulation and information

All the evaluation is divided into four big parts. The main objective is to be able to evaluate the correlation between the information necessary for simulation and the interests of the users (purple arrow) to provide this information. A second goal is to reach an agreement between the goals of the application and their realization (blue arrows) – to be able to evaluate technical aspects of it (Fig. 3).

WHAT	⟷	**HOW**
Information is necessary for the user.		What methods are used to provide user with appropriate information?
↕		
Information necessary for simulation (for a company interested in the research).	⟷	What methods are used to persuade user to give information?

Fig. 3. Division of evaluation metrics

People still have not much interest in energy savings [1]. Even the scientists that are puzzling over the new technologies on pr oducing and saving the energy, when it comes to the habits of energy consumption at home do not think about the effects of this habits on the environment. Persuade householders to use less energy is a hard goal to reach. However, it can be changed over time applying governmental support, for instance, Eco-taxes, or emission trading [3]. The same aim has the development of such science as ecological economics which is defined by its focus on nature, justice, and time. Issues of intergenerational equity, irreversibility of environmental change, uncertainty of long-term outcomes, and sustainable development guide both, ecological and economic analysis and its valuation [4].

For example, in June 2011, US government launched Green Button Programme [5], ergo all the householders could download metered data about the electricity consumption. Furthermore, they launched American Energy Data Challenge [6] for the development of the applications that could show the information about energy consumption in a user-friendly way.

The challenge is to involve society in a process of saving of energy, to change gradually people´s habits using comprehensive approach.

Therefore, an application that shows to a householder where and how he can save energy, explaining why this is important, showing how each improvement of the domestic electricity devices influences the environment, could provide significant changes in energy conservation strategy. There is a keen interest in the development of such applications.

Talking about environmental sustainability for any government, it is not only important for philanthropic reasons but for its economic stability.

For environmental companies the main goal is to save energy resources and to decrease carbon emission in order to reduce environmental damage caused by it.

The most important for the owner of the building is to reduce the cost of housing maintenance.

Finally, application developers just see it as an interesting puzzle to solve, absolutely immerse in the Internet of Thinks (IoT) paradigm.

Nevertheless, in the whole process every participant of the application development asks what will be his profit, what information is necessary, how to change people's habits but sometimes the user needs are not considered. What can persuade a p erson to tell about his consumption habits? what can be helpful to use the application?

In order to provide user with necessary information in a convenient way we have developed a set of metrics. Taking into account, that, on the one hand, the evaluation of the application intents to be quite easy and fast. This gives us an understanding of what facilities will be provided in the application. On the other hand, it should be precise enough to evaluate the application developed comparing it with other applications.

The methodology of evaluation is based on the research shown in the article "*A discrete-event simulation and continuous software evaluation on a systemic quality model: An oil industry case*" [7]. However, this research is concentrated on t he metrics to evaluate educational features of the application.

To develop a set of metrics we had to examine prevailing tendencies on the market. In the following chapters it is explained why prevailing tendencies are behavioural science and gamification; how it helps to improve EMS; what possibilities it uncovers for researchers and energy companies in order to provide environmental sustainability.

3 Tendencies on EMS market

It is important to follow the tendencies on the market of EMS in order to avoid to reinvent the wheel understanding that a good research can provide new ideas.

The main aspects to be considered during the development of EMS we highlighted are:

Simplicity: No difficult registration forms and no payment. Usual householders are not ready to spend their time or money on such applications, yet. Application has to be opt-out (come from an energy company as a d efault) [1] or vice versa not to show any connection with energy company because of common distrust of householders to energy companies [8]. The information should be given in easy-to-understand and user-friendly format.

Interaction: Mainly defined by competition or cooperation. (i) Competition: the householder can compare his usage of energy with others: friends from the social networks or the average user. Has the possibility to use some filters to compare his usage with others by the type of the building, the type of the apartments etc. (ii) Collaboration: users can give tips to other users in order to save energy; also they can use and save other users tips if they like them.

Motivation

Users can earn "coins" if their tips are popular and then spend them on t he discounts in real shops. The comparison itself makes the people excited and involves them in competition of saving the energy.

However, to apply these characteristics correctly, we had to search for assistance in such fields of science such as behavioural science and gamification.

3.1 Behavioural science

Some of the global players on t he EMS market appears to start using behavioural science as a key to engage customers in saving energy with the purpose of reduction the cost of energy production [9].

Systematic analysis and research of human behaviour permits them to preview customers' behaviour depending on the information we give them or the feedback we provide.

For instance, OPOWER Home Energy Report [10] outlines two key features: (i) 'descriptive norm' that indicates where consumers fall, relative to the average and their most efficient peers and (ii) the 'injunctive norm' (provided in the 'How you're doing' box, i n this case a smiley face –), that provides a social appraisal of the household's relative performance. However, due to the book "Yes! 50 scientifically proven ways to be persuasive" [11] unexpected influence of giving a feedback to consumer can be a "boomerang effect": when low energy householders' consumption can increase energy use due to social norms, encouraging energy-efficient users to continue to outperform the average [12].

With this consideration, the most important aspects we highlighted related to a EMS development are:

1. Show to the user that he is already caring about energy conservation. This is what is called foot-in-the-door technique. Once a person states that he does care about sustainability and understand that he wants to help, saving energy, it will be easier to involve him in the future participation due to his commitment to this first statement. People wants to show consistency because it is highly valued in our culture [13].
2. Involve users in the competition. Give notion that others use the application and save energy. Show that somebody in the closest neighbour environment saves more energy (and money) and teach how he achieved such success.
3. Teach appreciation. Give feedback on t he successes and failures; give simple tips to improve the results.
4. Divide information into easy-to-understand and complete blocks; do not ask user to add many data at once. Do it gradually [11].

These are four the most important aspects to begin, but not the unique. Next we are going to describe a powerful technique, gamification that can be used to enhance the user experience.

3.2 Gamification

"We always learn better when the experience is FUN" – states An Coppens, Chief Game Changer at Gamification Nation Ltd. [14]. One of the common use of gamification are serious games. They are a simulation of real world events or processes developed with the purpose to solve a problem [15]. The main objectives of serious game (if not taking into account entertainment) usually are to train or educate users. Gamification can be used to engage users in the process of saving energy without overloading him with large amounts of information. Just participating in a game user gets useful tips on energy saving. The gamified process has two main objectives: (i) to obtain information about users` habits, to provide closer-to-reality simulation for scientific needs; (ii) to give information to a user in order to teach him how to use energy proficiently. To engage a person in the interaction with a gamified application it has to provide user with four following characteristics [16]:

Challenge: There are two obvious reasons to manage energy: to spend less money on the energy bills and, if you are worried about the environment, to waste less energy. But based on the first rule of persuasion: there is no other such a powerful source of social influence as other people`s behaviour [11]. For instance, a competition can be a source of a challenging EMS.

Curiosity: If the information provided is accurate to reality, well-explained and shows relationships and connections that are not that obvious for an average customer, this information motivates him to see "*what else do they have for me*".

Control: Following the previous characteristic if person can add the changes and see the difference, see how his decisions change the situation in the application, he might try to apply these changes in real life to see if it really changes the bills. Finally, we have not only his engagement throughout the learning process but also contribution to the acquisition of new knowledge and application it to real-life situations [17].

Imagination: Some missions must to be more difficult so that the customer might use his imagination. This avoids to become bored with the application too fast.

With all those considerations, we review next the proposed metrics we develop in order to punctuate this kind of software.

4 Metrics

To develop the metrics there should be taken in consideration such criteria of evaluation (Fig.3):

1. From the point of view of interface and logics of the application, the metrics must be able to evaluate **simulation** and **educational features.**
2. The evaluation of **technical** features.
3. The metrics should be divided in two parts for evaluation **by software developers** and **end user**s, because some metrics that can be seemed clear by a t echnical user can be unclear for the end user. The developer is evaluating both physical and logical features whether end user evaluates only logical ones.

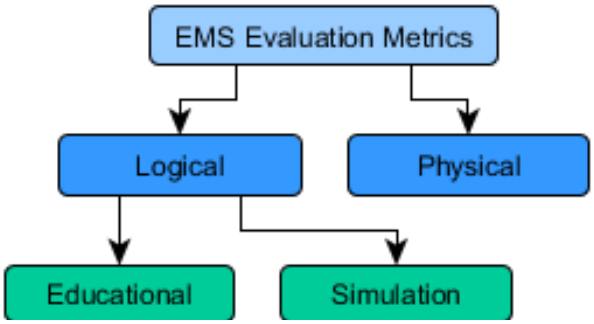

Fig. 4 EMS Evaluation metrics division

4.1 Logical metrics for educational features of application

As a basis for logical metrics in the educational part the article from [17], was taken In order not to overload the process of evaluation we have selected only the most important from the point of view of our goals criterions (Table 2).

5 Long list of Energy-related applications

The methodology we follow, based on [7], needs a list of software that are going to be evaluated. This list is defined starting from a long list that represents all the software that exist in the market (for the specific purpose).

This long list can be useful here in order to better understand the tendencies. Later the medium and the short lists can be used to understand the competitors we face in the case we want to develop a new EMS, or to select the appropriate EMS for our specific purposes (thanks to the metrics evaluation), see [7].

5.1 Application types by the source of information

The applications were searched in the Internet in English, Spanish and Russian. So the sampling is not showing the worldwide tendency in this field but is quite representative as English is supposed to be international language and gave a possibility to divide them by types.

Table 2 shows the metrics we propose to evaluate this kind of software. The proposed metrics are useful not only to understand the features a specific software owns, but also to guide the development of a new EMS.

Table 1. Application types by the source of information

Type	*Description*
Game	Is not usually connected with the reality, gives the idea how to spend energy, advices in a form of a play.
Energy Management tool with the smart meter	Usage of smart meter allows to obtain quite informative real-time or near real-time data and then watch the changes in the application.
Power Management entering invoice data	The information added by you or provided by Energy Company automatically. You can only see the difference by period.
Energy costs simulator	Simulates your expenses based on comprehensive data you entered about your home.
Emanation of carbon simulation	Simulates the emission of carbon you produce based on energy used by your home and your lifestyle.

The types of applications can be merged to reach a clear picture of energy consumption and householders' habits. In addition, to involve user in sharing information about his habits it is very important to give him useful information back, to make him sure that the application serves his needs. In a table 3 we can see a long-list of applications that are developed in order to show the user how to save the energy.

Table 2. Logical metrics for educational features of application

Criterion	**Description and importance to the project**	**Scale**
1. Content		
1.1. Presentation	This is one of the most important blocks because we must balance the information we give to user that should not be obvious, avoiding overwhelming the user with tons of information.	1: Information is badly structured 3: Some blocks of information are presented better than others 5: Well-structured information
1.2. Accuracy		1: The information is not reliable 3: The information is not totally reliable 5: The information is reliable
1.3. Relevance		1: High 3: Medium 5: Low
1.4. Connection to the learning objectives		1: High 3: Medium 5: Low
1.5. Adequacy for the consumer		1: Does not meet customer`s expectations 3: Moderately satisfied with the application 5: Totally satisfied
2. Control	The ability of user to personalize settings by his needs. The possibility of adjusting content and settings	1: Low ability of control 3: Medium 5: High

	to meet specific needs of the customer.	
3. Meaningful Feedback	Important criterion to provide customers understanding. Good feedbacks can change customer`s habits.	1: Low ability of control 3: Medium 5: High
4. High-order thinking skills	Implies customer`s curiosity and imagination. Shows the development of knowledge.	1: The tasks are too easy/ not interesting 2: The tasks are too difficult, the user loses interest finally 3: The tasks have medium difficulty but the user is not captivated 4: The tasks are quite interesting but not difficult enough 5: Tasks are difficult but very interesting
5. Usability and technical performance		
5.1. Learnability	How easy is it for users to accomplish basic tasks the first time they encounter the design?	1: Difficult 3: Medium 5: Easy
5.2. Efficiency	Once users have learned the design, how quickly can they perform tasks?	1: It takes a lot of time 3: It does not take a lot of time 5: Quickly
5.3. Memorability	When users return to the design after a period of not using it, how easily can they re-establish proficiency?	1: It takes a lot of time 3: It takes some time 5: Easily
5.4. Errors	How many errors do users make, how severe are these errors, and how easily can they recover from the errors?	1: Many severe errors, difficult to recover from them 2: Low amount of severe errors, difficult to recover from them 3: A lot of insignificant errors, 4: Low amount of insignificant errors, difficult to recover 5: Low amount of insignificant errors, easy to recover
5.5. Satisfaction	How pleasant is it to use the design?	1: There is no comparison 3: Comparison with ideal situation or anonymous users only 5: Specific Users (friends in social networks)
6. Interactivity and engagement	Does the application show the information or involves user to participate in order to see this information.	1: Low level of interactivity and engagement 2: Low level of interactivity and medium level of engagement 3: Medium level of interactivity and low level of engagement 4: More than a m edium level of interactivity and engagement 5: High level of interactivity and engagement

7. Type of comparison	If there is any way comparison of to others.	1: There is no comparison 3: Comparison with ideal situation or anonymous users only 5: Specific Users (friends in social networks)
8. Need to solve missions	Using the imagination in solving user tasks playing educates and can use new knowledge into reality.	1: There are missions 5: There are no missions
9. Advice	Does the application give tips on how to spend less energy.	1: The application is not giving advices 3: The application gives advices 5: The users and the application gives advices

Table 3. Long list of energy-related applications

Project	Company	Link
NECADA	Politècnic University of Catalonia	http://www.necada.com
Kill-Ur-Watts	KeyLogic Systems	https://itunes.apple.com/us/app/kill-ur-watts/id527704643?mt=8
Wiser EMS	Schneider Electric's	https://itunes.apple.com/us/app/wiser-home/id470316647?mt=8
Energy Tracker	iOS Apps Austria	https://itunes.apple.com/us/app/energy-tracker/id428830805?mt
Energy Cost Calculator	VPUGAZHENTHI	https://itunes.apple.com/us/app/energy-cost-calculator/id531132387?mt=8
Green Outlet	Key Lime 314	https://itunes.apple.com/app/green-outlet/id329692231?mt=8
Nest Mobile	Nest Labs	https://itunes.apple.com/us/app/nest-mobile/id464988855?mt=8
Leafully	Trick Shot Studios	https://leafully.com/
Melon	Wegowise	https://www.wegowise.com/melon
GoodCoins	Zerofootprint	https://itunes.apple.com/ca/app/goodcoins/id864168291?ls=1&mt=8
Wotz	Students work	http://wotz.ps.uci.edu/
Drive Mobile App		http://challengepost.com/software/drive-mobile-app
GEMS	Green Impact Campaign	http://challengepost.com/software/gems
The Green Deal App	Green Deal Group	https://play.google.com/store/apps/details?id=com.red7mobile.android.greandeal
JoulBug	Cleanbit Systems	https://itunes.apple.com/us/app/joulebug/id391199306
My CO2 Calculator	Zero Above Ltd	https://play.google.com/store/apps/details?id=com.zeroabove.co2&hl=en
Standby Energy Cost Calculator	EmpMobile	https://play.google.com/store/apps/details?id=com.empmobile.standby.energy.cost

Meter Readings	Graham Haley	https://itunes.apple.com/us/app/meter-readings/id320551309?mt=8
OPOWER	OPOWER	https://social.opower.com/comparison/2014/11
Precio de la Luz	Neapp Soft	https://play.google.com/store/apps/details?id=com.neappsoft.precioluz&hl=es
Luz + Precio	the3devs	https://play.google.com/store/apps/details?id=com.the3devs.luzplus&hl=es
Boltio	Kinética Mobile	https://play.google.com/store/apps/details?id=mobi.kinetica.boltio.app
Tarifazo	AppEventos Mobile S.L.	https://play.google.com/store/apps/details?id=com.appeventos.tarifazo
Precio Luz	redpolas	https://play.google.com/store/apps/details?id=com.consule.consule
Green outlet	TerraPass	https://itunes.apple.com/app/green-outlet/id329692231?mt=8
CarbonFootprintCalculator	TerraPass	http://www.terrapass.com/calculate/
PowerMeter	Google	http://en.wikipedia.org/wiki/Google_PowerMeter
GreenQuest	EnergyCap	http://www.energycap.com/products
Hohm	Microsoft	http://en.wikipedia.org/wiki/Hohm
E4RSIM	E4RSIM	http://e4rsim.e4r.es/
Etres Consultores	Ahorra tu energía	http://www.ahorratuenergia.es/
Hog Busters Energy Hogs	Alliance to Save Energy	http://www.energyhog.org/childrens.htm
Kids Energy Zone	Touchstone Energy	http://www.kidsenergyzone.com/games/activitiesdetail63.cfm?activityid=8
Ollie`s club Energy Saving	Sustain Ability International	http://www.olliesworld.com/club/gamehouse.htm
Rubí Brilla	Enerbyte	http://enerbyte.com/enerbyte-rubi-brilla.html
iControl	iControl Networks	http://www.icontrol.com/
Control4	Control4	http://www.control4.com/
EcoFactor	EcoFactor	http://www.ecofactor.com/
Tendril	Tendril	http://www.tendrilinc.com/
Convert Energy Units of Measure		http://www.onlineconversion.com/energy.htm

6 Concluding remarks

This research gave us a possibility to define the main features of a EMS application. When one face with the development of a new EMS is needed to consider the drawbacks mentioned, analyse the market applications and consider the techniques of behavioural science and gamification to engage the user to use the application. This is absolutely need to obtain information from the user and, on the one hand, to provide him with proper feedbacks.

The proposed methodology, along with the proposed metrics, can be useful for the development of new EMS or for the selection of existing EMS.

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