Ener-SCAPE: A Novel Persuasive Game to Improve the Energy Consumption Awareness

Diego Arnone, Alessandro Rossi, Enrico Melodia
Research and Development Laboratory
Engineering I.I. S.p.A.
Palermo, Italy
email: diego.arnone@eng.it, alessandro.rossi@eng.it,
enricogabriele.melodia@eng.it

Marzia Mammina
DemetriX S.r.l.
Palermo, Italy
email: marzia.mammina@demetrix.it

Sandra Elizabeth Jenkins
Engineering Systems Division, Technology and Policy Program '14
Massachusetts Institute of Technology
Cambridge, MA, USA
e-mail: sandjenkins@gmail.com

Abstract— **Ener-SCAPE is an educational game, relying on a novel software framework, whose main aim is trying to improve the awareness of the energy consumption of its users, at home where they live, as well as in the office where they usually work. Players participate by trying to exit from their home or office, by improving some predefined energy efficiency indexes which show the environmental performances of the place. The software application uses a common escape room game framework, tailoring the game archetype to focus on energy efficiency and consumption awareness. Furthermore, Ener-SCAPE implements a novel feedback mechanism based on real energy consumption that induces consumers to apply what they have learned from the virtual reality of the game into their daily real lives.**

Keywords-energy-awareness; ***serious game***; ***educational game; escape game; virtual currency; energy consumption; energy efficiency; social network interaction.***

I. INTRODUCTION

World energy consumption is steadily increasing, despite mitigation efforts, particularly in the countries that are having a great economic growth. This is a global issue for the environmental protection as well as an economic and political issue for countries dependent on foreign energy supplies.

In order to address increasing consumption, many solutions are being proposed and implemented: incentives for renewable energy sources, new technologies for highly efficient buildings, new technologies for more efficient appliances, more sustainable transportation, etc. However, the aggregate energy consumption behaviour of the general population is responsible for a significant percentage of the overall energy consumption worldwide. For this reason, the energy policy adopted by many countries is focused on Energy Consumption Awareness (ECA). The main factors that may influence energy consumption behaviours of citizens are environmental education, real time control of energy consumption, involvement of young people and greater energy consumption awareness. Thus, ECA policies can be strategic for the reduction of energy consumption.

With the growing number of products and devices in homes and offices, learning and keeping up to date with energy efficiency measures can be difficult. However, as more devices are able to communicate with each other, consumers are going to increasingly look for more innovative and accessible ways to manage and learn about energy efficiency. It is essential that all citizens are "energy aware", because improving energy efficiency does not mean that people should give up activities to save energy. Rather, new technologies and more effective behaviour will actually allow citizens to do more, improving their living conditions without compromising their standard of living. Furthermore, while the improvement of energy efficiency means lower costs and greater sustainability, it is also a great opportunity to stimulate economic growth.

This work aims at following and going beyond the series of current initiatives. Through a novel application, our goal is to improve the energy consumption awareness of people both at home and in the office by employing three features: (i) a well-known and successful game model, (ii) a real-time intuitive feedback on consumption and (iii) a strict collaboration with other players/consumers.

In Section II, the state of the art of serious and pervasive games is briefly reported. In Section III, the Ener-SCAPE applications are fully described. In Section IV, the conclusions are given.

II. LITERATURE REVIEW

In the last few years several institutions, including the European Union (EU), have become increasingly committed to promoting a higher awareness of energy consumption. With this aim, the EU has launched several initiatives and published several documents, especially directed at children and young adults. In addition, information campaigns for

 ISBN: 978-1-61208-406-0

greater awareness in energy consumption, not only directly related to public institutions, have spread. Nevertheless, these are actions that will produce long-term results; particularly, those focused on children which can get significant results across generations [1].

In order to obtain immediate results, feedback on consumption is frequently adopted to improve the energy awareness. Research projects, like BeAware [2], or commercial products, like Energy Orb [3], aim at motivating users to be more responsible in their use of electric appliances by showing real-time energy consumption feedback through an intuitive user interface. Recent studies demonstrate that this kind of feedback alone is enough to reduce the consumption by 23% to 27% [4]. Moreover, persuasive technologies have proven useful in modifying behaviours related to energy usage. A relatively unexplored potential way to drive awareness is through the development of the so called "serious games", i.e., interactive virtual simulations whose fundamental purpose is the development of the user's abilities and skills in a simulated environment, so they can be then applied in the real world. Ecoville [5] is a web-browser simulation game that develops a city and its population, handling the energy balance, CO_2 emissions, garbage disposal, etc. EnerCities [6] takes this concept further, based on the Theory of Planned Behaviour [7], where players have to balance three variables: population, planet, profit. Power Agent [8] and Power Explorer [9] are two "pervasive games" that put family members in competition to reduce domestic consumption, as measured by sensors, and points out the difference between players' and non-players' behaviours utilizing an avatar to help convey best practices in energy efficiency.

Even though there have been relatively good results, serious games still remain a "niche" field. The main limits to their popularity are their target audience (scholars and families, often very different from the average users and surely far from the player community), the perception that educational games are boring, and the lack of entertainment and achievement typical in traditional games. One of the most downloaded mobile games, Angry Birds [10], is a very simple physics based game. As many other F2P ("free-to-play") games, it is an example of the translation of various objectives (commercial, in this case) into gaming ones (credits, in-app purchases). F2P games strength lies in their simplicity, intuitive interfaces, and their repay value. Moreover, applications like Farmville [11], a farming simulation social network game, demonstrate that people like cooperative games in large online communities, consisting of traditional gamers and non-gamers alike.

Ener-SCAPE is meant to exploit the strengths of serious games, while overcoming their weaknesses, by posing them in a new light to make them more entertaining and, thus, more likely to be successful.

III. ENER-SCAPE

Ener-SCAPE is a persuasive game aiming at improving the awareness of energy consumers both in their homes and in buildings where they usually work. Players are tasked with escaping from their apartment or office by solving rebus puzzles, through the use of specific information and the implementation of strategies. Improving energy consumption behaviour in the game helps the player to earn virtual currency redeemable for an easy escape. By simulating real situations, the information and sensations experienced remain strongly impressed, and, thus, allow the player to sharpen perception, attention and memory by promoting behavioural changes through "learning by doing".

Two versions of the game Ener-SCAPE are being developed: one related to a home environment and the other to a building/office environment.

Both versions include and integrate three different applications: a dashboard for monitoring real consumption, which shows performance indicators and hints to improve performance, an escape game (Point & Click), and a tool for integration with social networks (Facebook/Twitter) to allow collaboration between players/consumers. The innovative aspect of the proposed approach consists of a simple but effective mechanism to integrate the three applications with the aim of converting existing successful models to an "edutainment" (education and entertainment) function.

The cornerstone of the Ener-SCAPE game, as previously introduced, is essentially to escape from a house (or a building in the second version of the game) as in any escape-game. Escaping can only be achieved after the resolution of a sequence of rebus puzzles (find items, combine them, use them, look for clues, piece together clues, gather information, find combinations, compose puzzle, solve riddles, etc.). The main feature of the game lies in the themes of each action: eco-sustainability, savings, efficiency, and energy-awareness. The most innovative aspect of the proposed application is the feedback from the real world. The game is integrated with a very simple and intuitive interface (monitoring dashboard), which processes the data collected through a sensing infrastructure and allows the consumers to see their real energy performance. The application allows the users to compare their current energy consumption with the historical average values.

While playing, users acquire information (gained from the game or the social networks where they get useful tips for solving puzzles) which can also be used in the real world. The ultimate aim of the game is impacting the consumers' behaviour in their real life. The monitoring dashboard provides a means to measure performance improvement, which is then translated into virtual currency which can be spent in the game to ease an escape. In order to facilitate the solution of a rebus puzzle, the users utilize the virtual currency that they can obtain from both their real performance improvements, and their social network interactions. The user can cooperate with other consumers in specific social network groups : each consumer builds his or her own reputation by cooperating with the community in solving the escape room rebuses as well as in achieving better energy performance in the real world. Reputation is also translated into virtual currency.

In this way users at home will strive to improve their behaviour by trying to reach the optimal values of real performance indexes. Therefore, as can easily be seen from Figure 1, Ener-SCAPE implements a beneficial cycle that

 ISBN: 978-1-61208-406-0

allows the consumer to learn about how to efficiently use energy simply playing the game [12]. At home, the user can save or waste energy. Then, the dashboard graphically represents the real performances coming from a sensing infrastructure installed in the home. The transition from the physical world to the virtual one corresponds to the translation of the real results into virtual currency that affects the consumer's ability to solve the rebuses in the virtual escape room. Finally, the beneficial cycle results in simulated solutions, information the user collects, applied hints, cooperation with other players, monitoring virtual performance, and sharing ideas inside a community. In this way, players may become consumers with increased energy consumption awareness that can help them to detect inefficiencies and improve their energy behaviour.

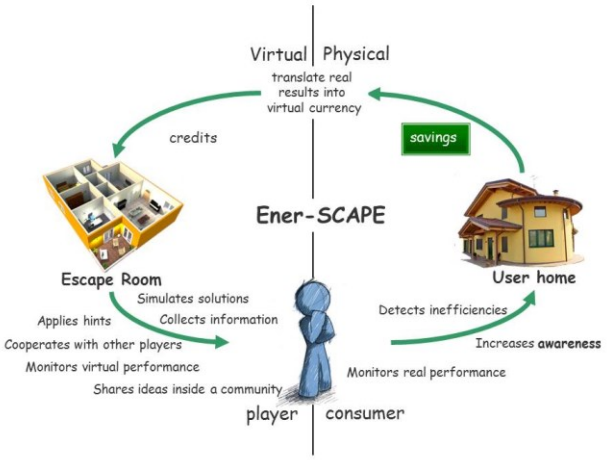

Figure 1. Ener-SCAPE approach to energy consumption awareness (home environment).

The game environment has been designed to be as physically attractive as possible, through a good quality architectural rendering.

Finally, the application was designed to be used from both Personal Computers (PC) and mobile devices, such as smartphones and tablets, in order to meet the requirements of accessibility and to avoid limiting the game to a single kind of device.

Figure 2 shows a mock-up of the game in the tablet version in the home environment. On the right, there is a basket where discovered items are collected; at the bottom, there are some widgets where players can view their virtual and real performances, as well as their scores and hints. Figure 3 shows a mock-up of the dashboard in the tablet version in the home environment. The monitoring interface includes diagrams which give the users a representation of their consumption and performance. In particular, through these diagrams, they can check their current consumption and the ideal average consumption for similar classes of consumers. Improvements in energy performance are translated into money (virtual currency) that can be spent in order to virtually buy needed items in the game.

Figure 2. Mock-up of the game (tablet version) in the home environment.

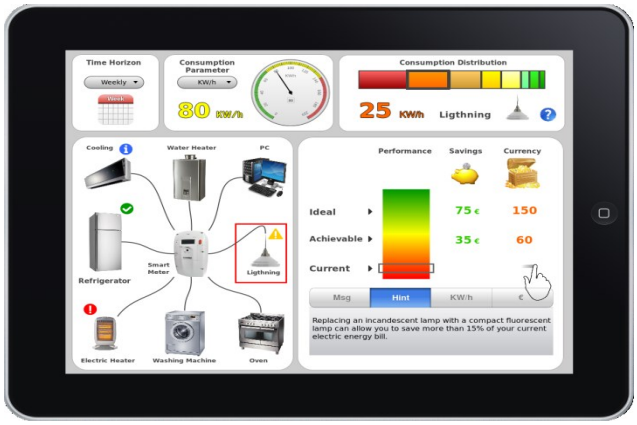

Figure 3. Mock-up of the dashboard (tablet version) in the home environment.

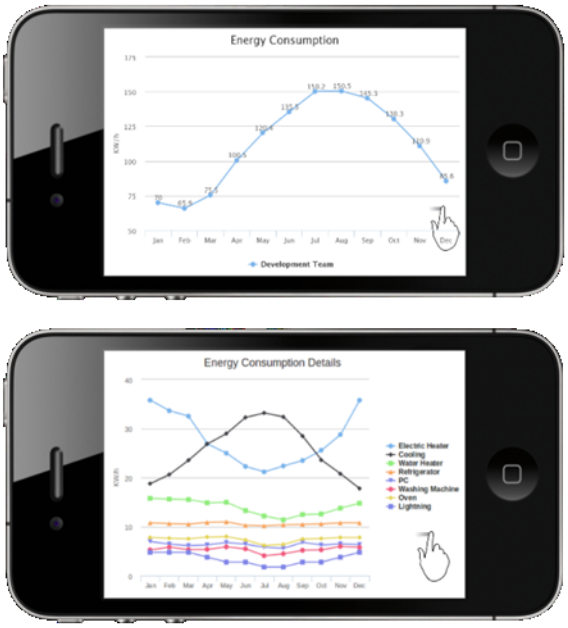

Figure 4. Energy consumption diagrams (smartphone version).

The access to energy consumption and performance values is enabled in multiple ways: by selecting household appliances in the star structure that represents the set of monitored devices (see Figure 3), or by selecting a consumption category (e.g., heating, lighting, appliances, sockets etc.). The user may also access focused hints and check any possible abnormalities in their consumption caused by inefficiencies.

As already mentioned, users can also compare their current consumption with their historical consumption, as showed in Figure 4 which depicts the dashboard for smartphones.

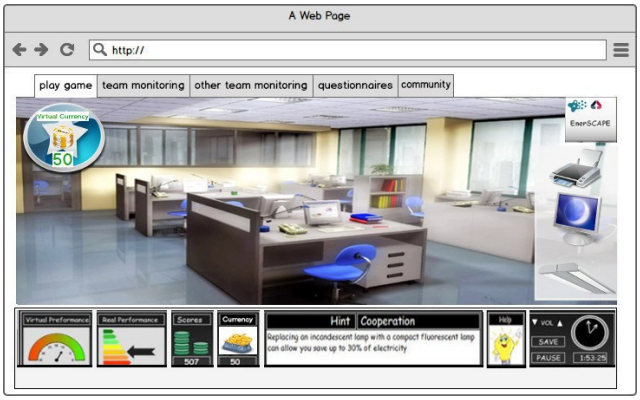

Figure 5. Mock-up of the game (PC version) in the office environment.

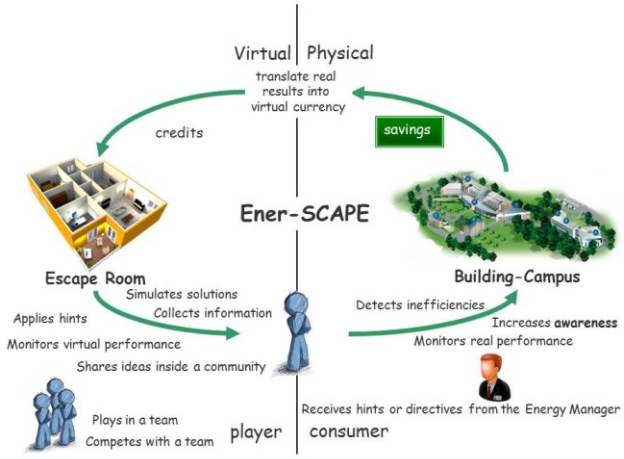

Figure 6. Ener-SCAPE approach to energy consumption awareness (building environment).

The game version for an office environment (see Figure 5 for a mock-up of the PC version) has only one significant difference from the one for the home environment: it is an escape game played in teams. The basic idea of the game is identical to the previous one, but with additional consideration of other actors besides the user/player: the energy manager (responsible for the coordination, management and efficient use of energy resources in the building/field) and other users/players, who, being in the same environment, are energy consumers as well. In this case, a mechanism for collaboration among users belonging to the same team and competition with other groups/teams of users is implemented. Members of the same team can exchange tips, information, and objects in the virtual world where they move and every player can constantly see not only the results of his/her team but also the results of other teams. In order to improve the energy performance the building(s), the energy manager will oversee the progress of the game by having the opportunity to suggest changes in behaviour, precautions, or to impose guidelines. Furthermore, as with the home environment case, the user may take advantage of social networks as an important resource to acquire information and to earn virtual currency.

The beneficial cycle previously described for the office environment is represented in Figure 6.

IV. EXPERIMENTATION PLAN

Ener-SCAPE is under development and no experimentation phase has been started yet. Nevertheless a plan to validate the proposed approach has been defined. Since the application integrates components already known to users neither acceptance problems nor transients for the achievement of a steady operation are expected.

Some metrics have been identified to evaluate the results and have been divided into quantitative metrics and qualitative metrics.

Quantitative metrics measure the effects of greater energy awareness. No preliminary consumption baseline is provided for the evaluation of the performance: users are clustered on the basis of a set of parameters (age, job, education, skills etc.) they provide during a preliminary registration phase and their performance, both in a home and in a building/campus environment, are evaluated on a well-defined set of time slots (hour, day, week, month, etc.) and compared to their own past average values or to the values of users belonging to the same cluster (e.g. the best user, the average one or the worst one). It is assumed that in order to have a greater persistence of the results it is needed to acquire and assimilate slowly a massive amount of information that will have significant impact on the lifestyle of the consumer, rather than only on the performance recorded during the experimental period. The impact of Ener-SCAPE is expected to increase slowly with time, so that the comparison to the average performance, in the first part of the use of the application, can be considered as the comparison to the baseline.

Qualitative metrics are subdivided into indirect metrics, aimed at assessing the user perception of the Ener-SCAPE application, and direct metrics, aimed at evaluating the effectiveness of Ener-SCAPE by evaluating the sensitivity acquired by the user in the field of eco-sustainability. In both cases, we intend to proceed by administering questionnaires to users. The feedback will allow to activate an iterative process in defining new requirements for the final prototype of Ener-SCAPE. The involvement of users will allow reaching a better understanding of their needs for the

 ISBN: 978-1-61208-406-0

achievement of the aims of the application that will allow the creation of a usable product appropriate to the context of use.

V. CONCLUSIONS

This work has proposed a persuasive and universal application to improving energy consumption awareness by designing and developing an energy-aware application based on an escape room game. The application will prove how the adoption of a well-known game model, as well as its integration with real-time consumption feedback and social collaboration, can significantly improve the energy consumption awareness both at home and in office environments.

ACKNOWLEDGMENT

This work is part of “ENERGETIC – Tecnologie per l’Energia e l’Efficienza Energetica” project, co-funded by MIUR (Italian Ministry for Education, University and Research) by means of the national Program PON R&C 2007-2013, project, PON02_00_355_3391233C.

REFERENCES

[1] EUROPEAN COUNCIL - 25/26 MARCH 2010 - Europe 2020: a New European Strategy for Jobs and Growth. [Online]. Available: http://register.consilium.europa.eu/pdf/en/10/st00/st00007.en10.pdf [retrieved: March, 2015].

[2] BeAware, "Home page," [Online]. Available: http://www.energyawareness.eu/beaware/ [retrieved: March, 2015].

[3] Ambient Devices, "Energy Orb," [Online]. Available: http://www.ambientdevices.com [retrieved: March, 2015].

[4] The Brattle Group, "BGE Smart Energy Pricing Pilot," [Online]. Available: http://www.brattle.com/_documents/uploadlibrary/upload768.pdf [retrieved: March, 2015].

[5] Ecoville, [Online]. Available: http://www.ecovillelejeu.com [retrieved: March, 2015].

[6] EnerCities, "Home page," [Online]. Available: http://www.enercities.eu [retrieved: March, 2015].

[7] I. Ajzen, "The theory of planned behavior," in Organizational Behavior and Human Decision Processes, vol. 50, iss. 2. pp. 179–211, October 1991, doi: 10.1016/0749-5978(91)90020.

[8] A. Gustafsson, M. Bång, and C. Katzeff, “Evaluation of a Pervasive Game for Domestic Energy Engagement Among Teenagers,” in Computers in Entertainment (CIE), vol. 7, iss. 4, art. 54, December 2009, doi: 10.1145/1658866.1658873.

[9] A. Gustafsson, M. Bång, and M. Svahn, “Power Explorer – a casual game style for encouraging long term behavior change among teenagers,” in International Conference on Advances in Computer Enterntainment Technology, pp. 182-189, October 2009, doi: 10.1145/1690388.1690419.

[10] “Angry Birds,” Rovio, [Online]. Available: http://www.angrybirds.com [retrieved: March, 2015].

[11] “FarmVille,” Zynga, [Online]. Available: https://it-it.facebook.com/FarmVille [retrieved: March, 2015].

[12] EscaperRoom24, [Online]. Available: http://www.escapegames24.com/ [retrieved: March, 2015].

 ISBN: 978-1-61208-406-0