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GAMIFICATION FOR ELECTRICITY USE PROFILING

IGRIFIKACIJA ZA PROFILIRANJE UPOTREBE ELEKTRIČNE ENERGIJE

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Abstract: Over the last two decades we are witnessing an accelerating paradigm shift in electricity grids and markets. The power grid, enabled by technologies such as renewable energy sources (RES), microgeneration, telemetering and telecontrol, is required to move towards demand side management, under the pressure for energy saving and low carbon economy on the one hand and electricity market deregulation on the other. Demand side management requires the user to be an active agent interacting in real time with the grid and the markets rather than a passive consumer whose only interaction with the grid is paying the bill and reporting faults. Under this light, the majority of electricity users could be considered as technologically illiterate, lacking fundamental knowledge and skills, which hinders the uptake of technologies and distorts related policies. The gamified application presented in this work combines persuasive and serious game technologies to educate users in electrical energy consumption, production and markets and engage them in energy saving behaviour, relevant techniques and technologies, while, at the same time, enabling them to transfer the skills and knowledge acquired to the real world. To these ends, our application uses the cognitive approach to develop educational material for the users' capacity building, gamification to motivate, engage and trigger users to form their own-shaped learning curves towards controlling their energy profiles, and SCADA technology to link the virtual to the real world. The proposed methodology can be applied to educational as well as commercial gamified applications.

Keywords: electricity user, behaviour modification, cognitive model, gamification, zero energy buildings

Sažetak: U protekle dvije decenije svjedočimo ubrzanoj promjeni paradigme u elektroenergetskim mrežama i tržištima. Elektroenergetska mreža, opremnjena novim tehnologijama kao što su obnovljivi izvori energije (RES), mikroproizvodnja, telemetrija i telekontrola, kreće se prema upravljanju potrošnjom energije (DSM), pod pritiskom energetske štednje i nisko-ugljične privrede s jedne, te deregulacije tržišta električne energije s druge strane. Upravljanje potrošnjom zahtijeva od korisnika da postane aktivan agent, koji – u stvarnom vremenu – vrši interakciju s mrežom i s tržištem, umjesto što je pasivan korisnik, čija je jedina interakcija s mrežom kroz plaćanje računa i prijavljivanje kvarova. U tom kontekstu, većina korisnika energije bi se mogla smatrati tehnički nepismenima, bez osnovnih znanja i vještina, što sprečava primjenu tehnologije i narušava povezane politike. Primjena igrifikacije, koja je predstavljena u ovom radu, kombinuje uvjerljive i ozbiljne tehnologije igre u svrhu obrazovanja korisnika o potrošnji, proizvodnji i tržištima električne energije, te ih uključuje u sistem štednje električne energije, relevantnih tehnika i tehnologija, a istovremeno im pruža mogućnost da ta stečena znanja i vještine prenesu u stvarni svijet. U tu svrhu, naša aplikacija koristi kognitivni pristup razvoja obrazovnih materijala za izgradnju kapaciteta korisnika, igrificira u svrhu motivacije, angažovanja i navođenja korisnika da formira vlastite krivulje učenja u svrhu upravljanja vlastitim energetskim profilom, i pruža im SCADA tehnologiju u svrhu povezivanja virtualnog i realnog svijeta. Predložena metodologija može se primijeniti u obrazovanju, kao i u komercijalnim, igrificiranim aplikacijama.

Ključne riječi: korisnik električne energije, modifikacija ponašanja, kognitivni model, igrifikacija, nulte energetske zgrade

INTRODUCTION

Over the last decades, the deregulation of electricity markets, the rapidly increasing penetration of Renewable Energy Sources (RES) and the advances in ICT technology have led to the smart grid and demand side management paradigm as opposed to the conventional transmission grid and supply side management. In the new paradigm, the electricity user interacts in real-time with the provider, the grid and the markets. The electricity user behaviour must be therefore considered as an active agent in the future grid design and control as well as in achieving the EU energy targets [1].

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Behaviour modification models and tools from the field of psychology may prove useful towards shaping savvy electricity end users. Gamification [2], which has found applications in the field of digital media and marketing for the last decade, is a technology that is being considered for behavioural modification [3]. It has already been applied in several educational environments such as e-learning platforms, or as a teaching method [4]–[7], as well as in commercial applications in order to emotionally commit and engage users [8]. As a relatively new tool, it has attracted a lot of controversy, especially concerning its application in the educational process [4]–[7].

In this work, we present the gamification methodology for developing an educational application for tablets and smart phones to train electricity users to their new role as active prosumers in the smart grid. This work aspires to provide the roadmap towards developing applications aiming to engage users in an interactive learning process which may also lead to behaviour modification, if this is a desired goal.

Most existing energy related games or gamified applications aim at raising ecological awareness at relatively young ages or allow the calculation of the energy consumption and CO2 emissions of appliances or devices. Certain applications, such as Electrocity or Energy Ville, are adult strategy games employing energy related narratives.

The proposed application aims not only at educating or entertaining but also modifying the behaviour of adult electrical energy users. To achieve this, the application's content addresses the cognitive, emotional and social area of the user [6], [9]-[11]. The application is designed as a game of quizzes, simulation and role playing with educational content and a narrative of every day habits, chores and activities. However, it goes beyond the virtual game environment and enters the real world via a smart meter device that allows the user to relate and apply the acquired knowledge and skills to real life.

The paper is organized in four sections. Section 2 describes the application's architecture and building blocks. Section 3 presents the creation of our proposed methodology used for the content development. Section 4 discusses how the linking of the application with the proposed methodology was implemented and last but not least in Section 5 the full gamified application is presented and its capabilities and limitations are discussed.

1. APPLICATION ARCHITECTURE AND BUILDING BLOCKS

The application (Figure 1) consists of the following components:

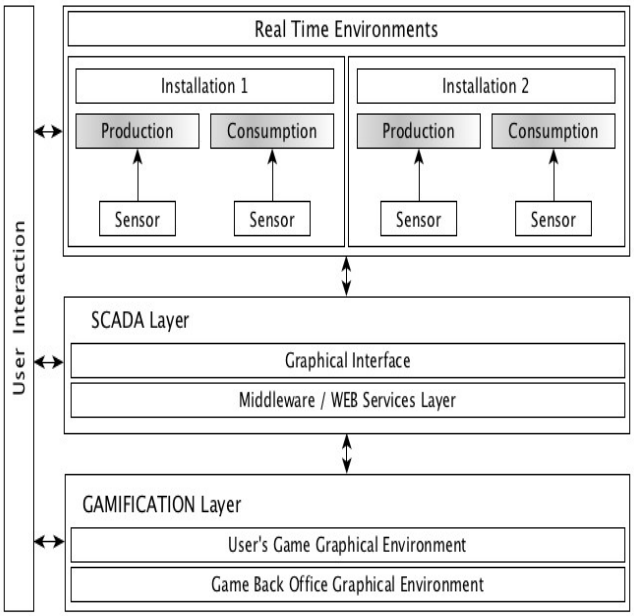


Figure 1: Application architecture

a) The gamification layer which consists of the front-end graphics and the back-office game components.
- The game graphical environment is an application, developed for mobile devices running on Android and iOS as well as for desktop web browsers. The gamified content was developed using the UNITY game engine, which is the state-of-the art tool for 2D/3D graphics and video content for development cross platform games and simulation software. The graphics, as e.g.in Figure 6, reflect the game narrative which is described in section 4. The interface is on purpose similar to that of social media and other web or mobile applications, e.g. Figure 4, allowing the users to interact, enter data or receive notifications in a manner they are familiar with.
- The back-office consists of a content management system (CMS) and a proprietary gamification platform. The CMS is that part of the gamification platform from which we import the content that is displayed in the application. The gamification platform is the part which supports the game mechanics, described in section 4, and applies them to the content based on the users' actions.

b) The SCADA layers responsible for the communication between the physical and the gamification layers. It consists of a graphical interface and a Middleware / WEB services layer that support the monitoring and controlling of the devices of the physical layer. It contains REST APIs that enable the definition of functions performing requests between the end user device and the cloud or internet and receive responses via HTTP protocol, such as GET and POST.

c) The physical layer serves the 'MyHome' level of the game and consists of actual metering equipment installed in actual buildings. This layer is further described in section 4.

Figure 2 depicts the three logical nodes of the application's architecture. Node 1, represents the back office platform. It hosts the gaming subsystem which can be a proprietary one like the one used to develop the pilot application presented in this work or an open one with similar functionalities. The gaming subsystem has two user interfaces: a "standalone" and a "social" mode. The latter supports all the functionalities of the former as well as the social dimension of the game and related to mechanics such as leaderboards, communication with social networks, relevant virality processes etc.

Node 2, represents the software acting as middleware between the gamification platform and the "MyHome" component. This layer supports the necessary functionalities through which the users access real time statistics of actual buildings they monitor as well as the user-friendly graphical interface of web services offered for real time monitoring and control of these installations.

In the absence of the necessary hardware, e.g. smart meters, necessary to monitor and control an actual installation, Node 1 operates independently of Node 2.

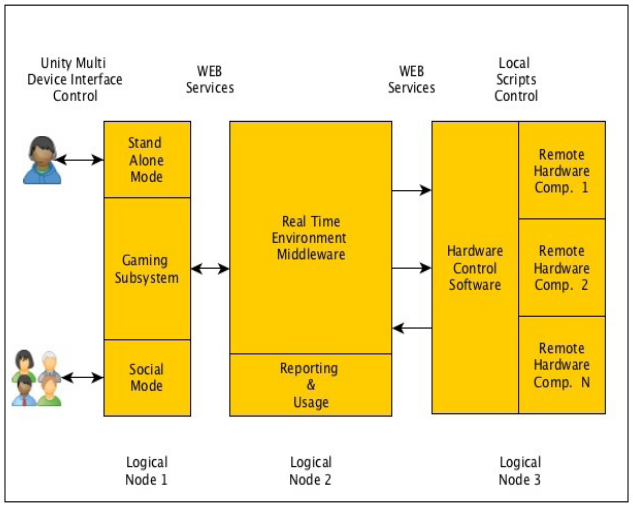


Figure 2: Logical Architecture Diagram

Node 3 represents the actual hardware components. These are assigned and used on a per registered user basis. Each user may have more than one installation (home, office, or other) and each installation several sensors for consumption measurement and actuators for load control, depending on the devices that need to be monitored and controlled. A local micro controller receives and sends signals from and to the hardware following "commands" received from Node 2 (the middleware layer), via web services. Therefore, Node 2 controls and reports usage, upon request, to the end-user, assuming, in this sense, the role of a small-scale SCADA-type system. Node 3 can host any smart meter device with open architecture.

The application may run on any client device, mobile or not, independent of the specific hardware and operating system. As for the gamification backend and the intermediate middleware platforms, these may reside in the same physical installation, servers, databases or be completely separated residing in a cloud-based type architecture.

2. METHODOLOGY

A gamified application that targets the engagement of electricity users in actions and activities dictated by their role as prosumers in the new smart grid paradigm, targets effectively the modification of their behaviour. In our application this modification comes as a result of education on electricity usage and markets and training on the capabilities and limitations of this new role.

Fogg's behaviour model (FBM) [12] has been used for the design of the game as well as educational content. FBM has been chosen because it works well with gamification mechanics as well as with educational content.

According to FBM, for a person to be convinced to change his/her behaviour on an issue, he/she must satisfy three conditions: sufficient motivation, adequate capacity and efficient activation. The FBM plane (Figure 3) depicts the mechanism for leading an individual along a trajectory towards a desired behaviour. A person may be further or closer to the target behaviour and that depends on a variety of factors which fall under two orthogonal categories: his/her ability, A (depicted on the horizontal axis), and motivation, M (depicted on the vertical axis), for change. However, the required levels of ability and motivation are a necessary but not sufficient condition. At the right timing, when the individual is sufficiently able and motivated, the right trigger must be issued so that he/she actually implements change. According to FBM, the content of our application must accommodate simplicity factors for movement along the horizontal axis, core motivators for movement along the vertical axis and behaviour triggers at the right time.

The capacity or 'ability' A for change is determined by the simplicity of the steps or the actions required to implement change towards a certain behaviour. It is a function of six variables: money, m, time, t, physical effort, pe, mental effort, me, social deviance, sd, and non-routine, nr:

$$A = 1/f(m, t, pe, me, sd, nr) \quad (1)$$

A increases as long as the value of f decreases. Therefore the change in A depends on the decrease of any of the above factors, as long as the value of the rest does not increase significantly at the time of activation or triggering.

In our application, we have decided to control users' ability through education. Education reduces the mental effort, me, required for behaviour modification. A will be determined by me as long as the money, time, physical effort, social deviance and non-routine factors do not impose a higher barrier. Even though a detailed analysis of the FBM use in our application is beyond the scope of this paper, we give below an example for illustration purposes.

We postulate that understanding the electricity bill, monitoring the electricity consumption of one's house or evaluating the energy profile of an electricity user, are tasks that may be achieved through proper education and training. Let us now compare achieving these goals through a free mobile app or through attending a seminar with a registration fee. The app can be accessed through a mobile anywhere, anytime, while the seminar requires the physical effort of getting there as well as the respective time and money commitment. Fitting a seminar in one's programme means changing one's daily routine which may or may not be desired. Finally, the social deviance factor favours the app, especially in the case of younger people. In the above analysis, the ability of an individual to attain the stated goals may be increased through education and training received by using the app.

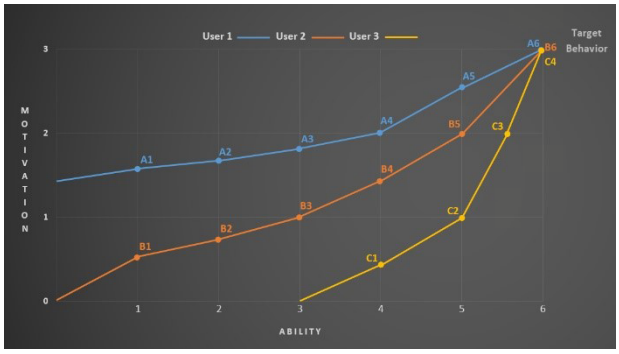


Figure 3: Trajectories toward the target behaviour, for three users with different initial ability and motivation

In order to develop the necessary educational content, an educational methodology is also needed. The cognitive learning process, on which student -centered learning is based, can be readily applied to gamified applications. It is a non-linear process that requires the student to shift from being a passive knowledge receiver to an active partner in the process, employing actions, rational thinking, and interaction with others and the environment, in an effort to give meaning to the topics that he/she attempts to understand or conquer. This process resolves the contradiction between what we know with certainty and what we think that others know on the one hand and what else we want to know or what we think we should know on the other. With carefully designed learning material and guidance through game mechanics, each user/student follows their own learning path. The learning material, reading and reference materials, quizzes, projects, etc., is organized according to Bloom's taxonomy [9]: *know*, *understand, apply, analyze, evaluate, create*.

According to FBM, motivation revolves around three dipoles: a) the pleasure/pain dipole which has an immediate effect on the user b) anticipated hope/fear which has a long-term effects) social acceptance/rejection.

Triggers are categorized into: a) sparks for unmotivated individuals, e.g. messages triggering any of the three motivators described above b) facilitators for individuals of low ability, e.g. tips c) signals, for individuals of sufficient motivation and ability, e.g. notifications for the right timing.

To implement the above in a gamified application, game mechanics, such as the narrative, levels, badges, awards, counters, leaderboards etc, are used. Game mechanics are necessary to increase the users' engagement and keep them engaged and active, in a 'flow state', through gradual increase in skill or challenge, as postulated by the 'flow' model [13], the indisputable model of most successful games. Skill can be mapped onto FBM's ability A axis while challenge may be related to motivation M.

In the proposed application, ability A increases through learning and skill acquisition and motivation M increases with the help of game mechanics. The latter are also used in the development of the learning materials well as to activate the user through appropriate triggering.

In developing the game's learning content, the major features of student-cantered learning process are included making use of the above-mentioned game mechanics. In the virtual game environment, feedback to the user is offered in the form of counters, awards and notifications, and in real world, in the form of real time measurements and notifications from the application's SCADA system. The social dimension of the application is served by both user-system and user-user interaction, in the form of messages, invitations, interactive content development, etc. Self-competition is ensured in the form of achievements. Competition against the other users, is effected via the use of leaderboards, badges and social media. Progression is guaranteed through the transparent profiling of each user and well-defined intermediate and ultimate goals. Graphics, colour and a narrative pertaining to real world situations are used to attract the user.

Movement along the M-axis is assisted by the following dipoles: a) pleasure/pain such as gaining/losing of points in the virtual game environment or gaining/losing money or comfort in real life b) anticipated hope/fear such as moving towards/away from mastering a game or learning level, or decreasing/increasing energy usage without compromising comfort levels in the real world; social acceptance/rejection such as scoring high/low on the game leaderboard or the ability to take part in discussions, exercise civil rights in the real world, etc.

3. THE APPLICATION

The potential users of the proposed application are all electricity users, regardless of age, race, sex, or economic background. Electricity users can be defined in the following broad categories with specific traits in their attitude towards the use of electrical energy: 1) domestic users who are responsible for paying the electricity bill of their residence 2) domestic users who are not responsible for paying the electricity bill of their residence, e.g. children economically dependent on their parents 3) users at the workplace or school who are not responsible for paying the electricity bill of the facility, eg employees in an office or students in a classroom 4) users at the workplace who are responsible for paying the electricity bill of the facility, e.g. building managers.

In our application, the target is to facilitate electricity users shift from being passive consumers in the conventional supply side management electricity grid to being active agents in the emerging demand side management smart grid and deregulated electricity markets. Using the architecture, building blocks and methodologies described in the previous sections, the proposed gamified application is a game of: a) simulation: because it simulates the consumption and production of electricity based on actual building requirements (residential or professional) b) strategy: because it requires the user to set objectives and use optimally the tools and resources provided to him c) learning & training: because there is material provided for the user's training to electricity issues through the application d) quizzes: because many of the 'tasks' of the application are multiple choice questions based on the above material.

The learning material is organized according to the Bloom's taxonomy starting from simple definitions and tips and escalating to more complex explanations and tasks requiring deeper understanding and insight.

Feedback is continuously given in various forms: points earned from accomplishing a task, such as reading suggested material or answering a quiz; personalized comments on quiz results; badges rewarding successful completion of tasks; hints or tips on critical points along the user's path navigating the application. The user may create his/her individual path to the top, selecting the specific objectives and activities offered.

The emotional content employs counters, badges (Figure 4) and awards to motivate the user and issue appropriate triggering based on the three dipole FBM motivators. The 'Smartege' leaderboard is called 'Tesla's Followers' (Figure 5) and the user's ranking in it depends on the points earned though the progress of the game. The leaderboard also appeals to the social area of the user since it displays the user's ranking relative to others'.



Figure 4: Indicative Smartege badges: The Effective, the Newcomer, Gone... with the wind



Figure 5: The application's leaderboard TESLA's Followers

The social content includes missions and tasks intended to shape the social profile of the user, to allow the user to form an identity, by triggering him/her to invite friends, share knowledge and tips, perform actions like "like" or "comment". In a later version, the user will also be allowed to form synergies with other users and compete against other teams, thus emulating a competitive electricity market where the application moderator has the role of the energy market regulation authority.

Finally, personalized communication is used for higher user involvement. The personalized data needed for this is accumulated through the user's actions as well as data entered by the user at various stages during the game as the user enriches his/her profile upon appropriate triggering.

4. THE GAME MECHANICS, DESIGN AND ELEMENTS

The narrative of the game is the following. The avatar, in the form of a light bulb, is a prosumer that manages the electricity consumption and production of a small apartment where it resides and an office space where it works. Both spaces may be equipped with standard electrical and electronic appliances and have the option of installing photovoltaics and wind generators. All of the above may be "purchased" from the "inventory" which offers a selection of such devices with specifications corresponding to actual commercial ones. The user is responsible for controlling the electricity consumption by scheduling the operating times of the consuming devices,

for deciding on the energy class of the appliances and the investment on electricity production units. The decisions made must be such that the electricity net consumption and cost are minimized while comfort is maximized. To make these decisions, the user will have to be educated, trained and informed by the learning material embedded in the application. The learning material is organized in the form of a library containing definitions, equations, explanations, tips, news, and other reading material about energy, power, voltage, current, power factor, energy efficiency, billing, electricity use profile, energy generation, renewables, etc. The reading material is complemented by quizzes and other missions. It is organized according to Bloom's taxonomy levels in such a way as to conform with the game's levels. Throughout the game, the user is asked to answer a set of quizzes in order to accumulate points which are used for the ranking of the user. These points play also the role of the user's accumulated capital which can be spent on electricity use, energy upgrades of the buildings or micro-generation. The level of complexity and difficulty of these quizzes is increasing with the user's progress in the application. If the user fails at such a test he/she is prompted to read appropriate educational material available in the 'library' and take the test again.

The game has four counters whose values are related to the point rewarding scheme of the game, the leaderboard ranking, the issuing of badges and awards, warnings, notifications, tips etc:

a) The 'Wallet points' increase when tasks and missions are accomplished. They decrease when they are invested in new higher energy class or energy generating devices and when they are spent to cover the use of electricity

b) The 'Electrical Energy counter' emulates the energy meter recording energy the net energy consumption, ie consumption – production, in kWh. The energy consumption depends on the usage of the electrical and electronic appliances installed in the building managed by the user. The energy production is due to the photovoltaics and wind generators installed by the user.

c) The 'Green bar' monitors the virtual building's energy class according to EU regulations. The building is classified under category A+++, A++, A+ and B, according to its yearly net energy consumption.

d) The 'Comfort bar' monitors the level of comfort in the building, following the user's actions, according to existing standards and design specifications [11]-[12].To urge the user toward realistic actions, it is important that the loss of comfort is penalized. It is therefore assigned a metric C calculated on a daily basis as follows:

$$C = \sum_i \left(\frac{Actual\ operating\ hours\ of\ i-th\ device}{Ideal\ operating\ hours\ of\ i-th\ device} \cdot W_i \right) \quad (2)$$

C is calculated as the weighted average of the ratios of the actual daily operating hours of the *i*-th device over the typical daily operating hours. The latter as well as their contribution Wi to a building's electricity consumption are determined from statistics and international standards for energy efficient buildings. The users' main quest is to maintain the values of the last three counters at such levels that the will be allowed to 'unlock' the next game level. There are 4 levels in the application:

- *The tutorial*: The first level is a tutorial. It is intended to be engaging and activate the user since it serves as the first impression of the user and, because it addresses most of the issues to be dealt with later on, is of high educational value. At this level, the user is introduced to the application's environment and offered a virtual 'tour'. The tutorial level is educational and therefore mandatory. It gives the user the opportunity to gain his/her first points, by the taking of the first set of quizzes. The user can move on to the next level only if he/she has completed a full tour of the tutorial at least once.

- *The Flat*: once the Tutorial Level is completed The Flat (or Residential) level (Figure 6) is unlocked. The user is called to select from the application's "inventory" typical home electrical and electronic appliances such as refrigerators, stoves, washing machines, dishwashers, TVs and computers, and position them in the Flat he/she is going to manage.

As the user navigates through the Flat, tips and information appear concerning the electrical characteristics and energy consumption of each device. With the help of appropriate triggering and educational material, such as recommendations, explanations and definitions, the user is led to schedule the operation of the selected appliances in order to optimize the electricity consumption as well as the comfort level in the Flat. The user may increase the energy class of all buildings under his/her control by replacing existing appliances and devices with others of higher energy performance. This costs 'Wallet points' which have been previously accumulated through the successful completion of tasks and missions. At this level, the user learns how to optimize electricity consumption



Figure 6: The 3D graphic user interface of the Flat level

without compromising comfort levels. Consumption is optimized through the shaping of the energy use profile and the energy upgrading of appliances and devices.

- *The Office*: The third level is the Office (or Professional) level (Figure 7) and concerns the energy management of an office complex. It is unlocked after the user has managed to reach A+ efficiency at the Residence level, utilizing the experience and knowledge gained so far. To attain the ultimate goal of net zero energy consumption buildings (nZEB), electricity micro-generation is necessary and therefore allowed from this level on. The user first learns to optimize the electricity use and consumption of all his/her buildings, residential or professional, and then is allowed to use 'Wallet points' to acquire and install electricity generation components. The concept of electricity production is a very important one in the game, since it allows the user to think of electricity as a resource and not simply as a costly comfort enabler. The user is also given access to educating material concerning electricity generation and storage devices, such as photovoltaics, wind turbines and batteries, as well as the relevant legal framework.

- *The MyHome*: The next and last level is the 'My Home' level, through which the user is given two advanced options:

a) Emulate the electricity use of an actual building: the user enters the power characteristics of the appliances of an actual home or office and sets their operating times according to their actual operation. This way the user can simulate the energy profile of a building of his/her choice, calculate the cost and understand the electricity usage of his /her appliances.

b) Obtain hardware compatible with the application and using the SCADA like component of 'My Home', described below, to actually monitor and control the appliances of a chosen building in real time.

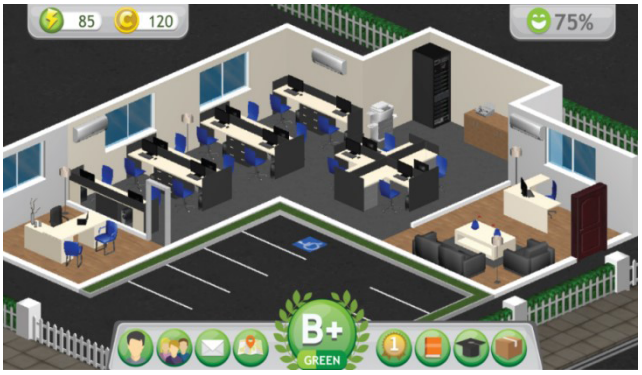


Figure 7: The 3D graphic user interface of the Office level

This hardware consists of commercial metering sensors and relay type actuators and a Linux based controller which communicates with the middleware layer and interacts, via the graphical interface (Figure 8), with the user. In terms of WEB services, we consider this as an Application Programming Interface (API). The application's SCADA is responsible for the input, management and output of data external to the system as well as the generated databases. These data are coming from the metering devices and relays installed at the distribution panel of the building that is monitored remotely by the user via the application. A layer of middleware composed of WEB services and a central SQL based database are used to maintain contact with and receive information from all remote installations. The watthour (Wh) counters are installed in each appliance or power line and transmit pulses according to the energy consumed. The granularity of the measurement, i.e. the number of Wh per pulse, can be set by the user. The pulses are transmitted wirelessly (IEEE 802.11b/g/n or XBee) or via Ethernet (IEEE 802.3).

The platform receiving the pulses can be "hosted" by any computing device provided that it is implemented in a very light way. The selected implementation, currently installed at the TEISTE Laboratory of Electrical Installations, is based on an ALIX.2D3 system, small enough to be wrapped in a cigarette size box, easily integrated into an apartment's central distribution panel. The ALIX.2D3 unit supports the Linux operating system and the following software components: a) *Wire File System (OWFS)*, a software component for the monitoring and control of the physical environment of the 1-Wire sensors/counters; it uses dedicated bash scripts to switch on/off an electrical relay, read from a sensor, write to a file data from sensors etc. b) *MySQL database*, is the database required for the storage of the time series data from the sensors and the source for the graphical representation of these data c) *PHP Engine*, used by the server to execute specific queries to the database (e.g. show me electrical consumption for a specific period of time). The JSON format is used for all reporting.



Figure 8: The 3D graphic user interface of the ''MyHome'' level

This way, the user controls the energy use of an actual installation with real time actions and representations in a user friendly graphical way. The user becomes aware of the building's energy profile, per power line and as a whole, learns to anticipate future electricity consumption and adjust behaviour accordingly.

A survey was conducted on electrical engineering students before and after the use of the application in order to measure the intervention in the users' behavioural modification [11], [12]. The results were satisfactory but, given the built-in bias of the sample, they served only as an indicator for future work. The application tests revealed flaws in the point rewarding mechanism which has a considerable effect on the 'flow' of the game. Current and future work involves the fine-tuning of the point rewarding scheme, the inclusion of more building profiles, developing a mechanism for extracting the profile of an application user for more personalized triggering and allowing the collaboration of users into teams and the competition between teams.

5. CONCLUSION

In this paper, we present a new pilot application for the training and behaviour modification of electricity users along the lines of the transition from the conventional to the smart grid. The application combines elements from the persuasive technology for behavioural modification, the cognitive model for the development of the application's educational content and the 'flow' model for game development. The three logical node implementation allows the user to manage and optimize a building's electricity consumption and production both virtually, via the game application, and actually via appropriate hardware and a SCADA like interface. The application offers the users the possibility to shape their own learning path towards understanding, monitoring, controlling and shaping their energy profiles in an engaging way. The methodology developed for building the gamified learning content will be used in e-learning course content as well.

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