Serious Game Design for Inclusivity and Empowerment in SmartGrids

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ABSTRACT
Demand-side management of electricity generation and supply requires increased attention to be paid to user engagement and active participation. However, the use of Smart Meters as a centrally-imposed and controlled technology monitoring someone else's behaviour, raising concerns about trust and privacy, is not, we believe, providing support for both inclusivity and empowerment which are prerequisites for user engagement and active participation. Therefore, instead of demand-side management, we believe that the emphasis should be put on demand-side self-organisation. To support this self-organisation, the user-infrastructure (i.e. grid) interface should observe certain design principles, including support for self-governance, multiple user roles and collective awareness. We propose the use of Serious Games to observe these principles and, at the same time, secure active participation of users, which maximises the capability of both individual consumers or groups of prosumers to make choices (inclusivity), and to convert those choices into collective action and desirable outcomes (empowerment).

Keywords
SmartGrids, Serious Games, Self-Organisation

1. INTRODUCTION
The traditional model of electricity generation has supply follow demand, with some minor variations, for example on-demand (as mostly experienced by domestic consumers), spot market, day-ahead market, and so on. The essence is the same: actual or predicted demand is determined and supply (generation) is scheduled and produced to satisfy that demand. The model has worked well enough until now, but various complications – such as over-provisioning of generation to accommodate peak demand – is having an impact if secondary targets, such as reduced carbon emissions, are also taken into consideration.

Furthermore, especially as it effects the domestic market, there are (at least) three other factors which are disruptive to this model. The first factor includes the regulatory policy for more electricity generation from renewable sources, which are generally stochastic in nature, making scheduling generators more complicated and costly. The second factor concerns the trend towards local generation (e.g. by domestic installation of solar panels) so that consumers become prosumers (i.e. both producers and consumers of electricity). Last one is the movement towards 'smart devices', which are more flexible in use (i.e. their operating cycle can be deferred rather than immediate). Scheduling millions of devices by centralised may not scale without hierarchical control [2]; but leaving such devices to their own decisions might create instability (e.g. if they all follow the market they select lowest prices; which forces the price up; so they 'flock' to the new lowest price, and so on) [15].

This has led to an increasing focus on demand-side management for electricity markets [20], and particular attention being paid to active participation or user engagement of consumers. At the same time, there has also been a steady roll out of so-called 'Smart Meters', an ICT-enabled device installed 'at the edge' of the electricity network, that allows both monitoring and reporting of electricity consumption, as well as two-way communication between the meter and the central system.

There has been (at least anecdotally) some resistance to the introduction of 'Smart Meters' in domestic residences, which is in stark contrast to the rapid uptake of 'SmartPhones' and their use of telecommunications. We would argue that the reason for this is because the latter is (mostly) an opt-in technology owned by the end-user which facilitates generativity (the innovation of new tools from old ones, not perhaps imagined or intended by the innovator of the old tools). The Smart Meter is a "can't-opt-out" technology both centrally imposed and controlled, which prohibits generativity, and is not owned by the user whose behaviour is being monitored, raising significant concerns for trust, privacy and security [23]. The 'intelligence', such as it is, is definitely not 'at the edge', nor is it operating on behalf of the end-user, i.e. the electricity consumer.

Our argument is that to address the demand side of electricity supply by active participation and user engagement requires inclusivity and empowerment, not disenfranchisement or deprivation of a meaningful stake or role in the 'market'.

In this context, we would go further, and argue that rather than demand-side management the emphasis should be on demand-side self-organisation. Here we are particularly motivated by Elinor Ostrom's principles of self-governing institutions for enduring and sustainable common-pool resource management [14]. In particular, we note the first principle on *clearly defined boundaries* (who is a member, and what resources are managed, are clearly delineated); the second principle on *collective-choice arrangements* (those affected by the rules of the institution should participate in their selection); and the seventh principle on *no interference by external authorities* (whatever rules the members of institution settle for deciding their affairs cannot be over-ruled by an external body). These principles are, we believe, the basis for inclusivity and empowerment in self-organisation.

The question then is: how to observe these principles and, at the same time, secure active participation of users? The answer, we believe, is to use Serious Games, in particular games in which Ostrom's principles are encapsulated by both the interface and the rules of the game, and the game itself maximises the capability of both individual consumers or groups of prosumers to make choices (inclusivity), and to convert those choices into collective action and desirable outcomes (empowerment) [10].

Accordingly, the argument developed in this paper is as follows. In Section 2, we review SmartGrids, the electricity grid infrastructure with 'added ICT', consider in more detail the drivers for demand-side management and the deployment of Smart Meters in domestic residences, and conclude with the requirement for Serious Games for demand-side management. In Section 3, we review the motivations for Serious Game technology and consider an example of where a Serious Game has been used in an auction scenario for electricity generation and supply. We then argue in Section 4 that we need to move from market-based mechanisms to self-organising mechanisms, where different incentives (such as social capital rather than financial reward) are paramount, and are essential to the success of a Serious Game. We describe a scenario and present a preliminary architecture and interface, which encapsulates Ostrom's principles, different users' roles, Smart Meters, information visualisation and collective awareness. We review some ethical and privacy issues in Section 5 and we include Current and Further Work in Section 6. We summarise and conclude in Section 7, arguing that serious games for adaptive institutions can help build collective ownership and awareness of national infrastructure, and improve the efficiency and fairness of its usage through inclusivity and empowerment based on an encapsulation and visualisation of Ostrom's principles.

2. SMARTGRIDS

SmartGrids generally refer to the use of Information technology and Communications to bring improvements in energy efficiency, reliability and sustainability of the electricity distribution and supply network. SmartGrids highlight the need of maintaing the network's infrastructure and improving the asset utilisation and the overall performance of the system. New government policies, laws and regulations have to be set and met for addressing the challenges of global warming and meeting targets for reduced CO_2 emissions, smooth peak demand, low electricity prices, increased network security, extended use of electric vehicles as an alternative storage option and so on. SmartGrids place a particular emphasis on the demand side management and they include demand-side, intelligent systems and advanced network technologies to provide real-time grid control and operation.

We argue that decision-support mechanisms for enduring, self-organising institutions in coordination with a 'smart' user-infrastructure interface can bring a better grid management and responds to climate change, carbon dioxide emissions, resource allocation and sharing, and other global challenges and changes. Demand side management based on a common-pool resource (CPR) management for self-governing institutions comes as an alternative to privatisation or centralisation of the energy network. A major challenge for grid administrators is to enable self-organisation, collective awareness and choice, thus facilitating rules to regulate and organise consumer behaviour and increase the user participation in the grid [14].

Consumers now have more advanced options and choices inside the grid, as they are empowered to take charge of their energy consumption and production and they gain an insight and understanding of grid sustainability. SmartGrids signify the importance of the consumer's inclusion and participation in the network, which requires not only a better understanding of the energy consumers' behaviour, but also getting energy consumers to better understand the effects of their behaviour and actions on the electricity network. Energy consumers can also be producers, who self-organise their own provision and appropriation rules in the context of an institution, especially in local micro-grids. We believe that the introduction of advanced communication and information technologies can help in the optimisation of the system, but an adaptation to users' behaviour and needs is required for making consumers active participants in the SmartGrids.

Energy consumers need to learn how to interact with these new technologies and the network infrastructure interface, something that tends to be ignored by SmartGrids, as they assume that consumers will somehow and automatically adapt to these modern technologies [10]. This negligence of the user-infrastructure interface hampers the active consumer participation and the Smart Meter which is the basic interface for displaying information, is conceived as a centralised and controlling technology, rather than as an innovation for enabling users and making their everyday lives easier [4]. Serious Games can be used as a critical requirement and innovative technology for demand-side management in SmartGrids.

3. 3D SERIOUS GAMES INSTITUTIONS

Serious Games can be investigated as a technology for demand-side management, especially for SmartGrids, where a house, equipped with all the electrical appliances and Smart Meters, can be visualised. The players can view their energy consumption, or they can use agent-based assistants which provide help and advices to players on how to save money by receiving reduced electricity bills or reduce the carbon dioxide emissions they produce.

3.1 Serious Games

Serious Games are digital games, simulations and virtual environments which purpose is not only to entertain and have fun, but also to assist learning and help users to develop skills such as decision-making, long-term engagement and collaboration. They are experiential environments, where features such as though-provoking, informative or stimulating are as important as fun and entertainment [12].

Serious Games can be used for modelling and simulating new and complex systems, empowering at the same time different groups and communities to exploit the most of the system's possibilities and characteristics. Serious Games can be used for teaching, training or raising awareness in many and different sectors such as education, health, military, energy, management and so on [11, 22, 5].

Serious Games enable users to develop new expertise and capabilities, while at the same time collaboration can be established among different players who are involved in a particular game for achieving a common goal. The design and implementation of a user-infrastructure interface based on a game can engage and motivate users. Users can observe changes in their performance or behaviour, long-term decisions and actions can be established, whereas active involvement and participation are favoured.

They are two different ways in which Serious Games can be used to support and promote user involvement and participation in SmartGrids. When Serious Games are used as normative virtual worlds, the users can have a direct and active participation inside the grid, whereas if they are used for training purposes, they enable users to better understand problems which concern resource allocation, prices, investment decisions and sustainability.

3.2 Example: Serious Games for an Electricity Market

A 3D Serious Game emphasising on demand-side management can be modelled by using Virtual Institutions (VI) [3] which is a combination of 3D Virtual Worlds (VW) and Electronic Institutions (EI) [7] which are organisations for implementing the interaction conventions between agents.

With the Electronic Institutions we can define and model the electricity market needed for SmartGrids (define all the different users' roles, the interaction and communication protocols, the rules that the players need to follow). The 3D VW provides the user interface which enables and encourages the user participation and interaction with the electricity market (SmartGrids). ViXEE (Virtual Institution eXEcution Environment) [21] is the VI infrastructure, which supports multi-agent communications and dynamic operation of the VW components. The player gets empowered and is included in the virtual environment by controlling his/her avatar (embodied character). The information visualisation is promoted and the players can have an overview of the whole environment (virtual household with appliances and Smart Meters). Moreover, the multi-agent environment supports the autonomous and un-predefined action and interaction, enabling at the same time the players to participate and communicate in a seamless and intuitive way (among them and with the virtual world). Figure 1 presents how different autonomous agents can interact and participate inside a VI by conducting gestures, communicating through private chat or displaying information on public boards.

Figure 1: Virtual World populated by 3D virtual characters performing collective arrangements (human-human and human-agent interactions)

The EI defines the rules of the game and structures the agent interactions, based on the following components: *ontology*; which defines the different scenarios in the game, different *roles* the players can enact and impersonate, different *activities* the players can have, various *protocols* that are needed to be followed and finally, a *performative structure* is needed where all the interactions among players are defined.

Moreover, Almajano et al. proposed an *Assistance Infrastructure* [1]which is composed of two different layers on top of a MAS (Multi- Agent System): i) the Organisation Layer supports the agents' interactions and manages all the data concerning the organisation and execution of the system, ii) the Assistance Layer, that is populated by a group of Personal Assistants (PA) which provide general Assistance Services to the participants. These Assistance Services provide help and guideline to users in order them to achieve their goals. In particular, general information about the system is provided; what the agents should do when they enter the system for the first time, or even support in the decision-making.

The above working example illustrates how Serious Games could be used as a technology for shifting the demand side management to a self-organising model, something completely different from the centralised and controlling technique being used nowadays. However, user inclusivity and empowerment with 'smart' technology should also address some specific requirements such as Ostrom's principles for self-organising Electronic Institutions, support of different user's roles, Smart Meters as non-player characters, information visualisation for comparative feedback and collective awareness.

4. SERIOUS GAME DESIGN

A digital game which emphasises on demand-side self organisation, rather than on demand-side management, should encapsulate a wide range of requirements. This would allow for support and enhancement of user inclusivity and empowerment in the system. Ostrom's principles, support of different roles, Smart Meters, information visualisation and collective awareness are some of the key requirements that should be addressed by the system in order to achieve its goals. This section discusses Serious Game Design in three interdependent parts. We start by giving a scenario for collective awareness in SmartGrids. We continue by defining and describing the different requirements needed for the demand-side management and we conclude by illustrating a user-interface.

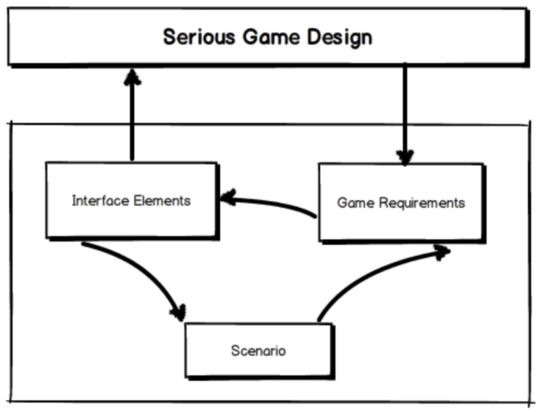

Figure 2: Serious Game Design

Figure 2 shows how these three interdependent parts are integrated for designing a Serious Game.

4.1 Scenario

In the energy sector there are many situations where problems need to be solved by involving either a big resource or an aggregated body containing a portfolio of smaller resources. For energy generation, the idea of the Virtual Power Plant has been proposed, where many small generation units are aggregated in an equivalent virtual bigger Power Plant. However, even a large number of aggregated units may not bring about a visible effect on the network if their efforts are un-synchronised. Traditionally, such aggregations are pre-organised and usually are backed-up by contracts. Instead, we require an approach whereby the minimal participation or 'critical mass' is reached with self-organisation and social contracts.

For example, consider the following scenario, in which a group of users are supplied from the same low voltage (LV) network (an LV network which is supplied from the same medium/low voltage transformer). In crowded distribution networks, there is a probability of power network overload – which can cause temporary network congestion, bringing under-voltage effects. The bottleneck is at the MV/LV (Medium Voltage/Low Voltage) transformer (Figure 3), which becomes overloaded during peak times. If its temperature increases too much, a protection trips the transformer and keeps it disconnected for some time in order to cool down. After reduction of temperature (with hysteresis), the transformer is re-coupled.

Presently, people do not know about this peril or do not care much about these issues. When the outage occurs, they just assume that energy supply is temporary stopped (1 minute, 15 minutes or even 2 hours) and ring the Customer Relations department to complain.

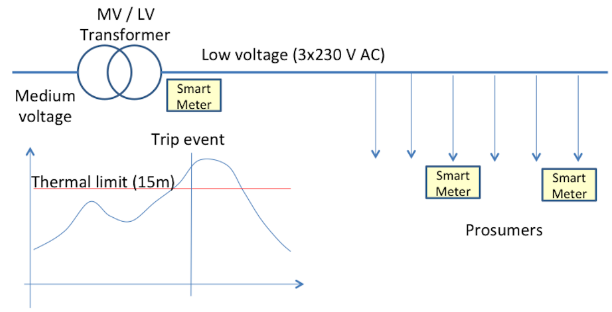

Figure 3: Trip Event in the Energy Sector

One approach to solving this problem is by increasing collective awareness, by enabling people to know more, or care more, about this issue, and organise and aggregate their individual contributions in order to solve a (collective) network problem. To do this, a three phase Smart Meter (SM) can be mounted at the MV/LV transformer and other smart meters are installed in domestic residences (DRSM). Various data from these meters can be read locally and remotely, for instance active and reactive power, voltage level, value of the current, consumed energy, etc. Reading the data-feed from the three-phase SM, the DRSMs can present a non-specialist visualisation of the MV/LV transformer load. Domestic prosumers monitor this information resource (for example, a panel in a 3-D virtual environment), where the system interface gives different data visualisation: e.g. notification about the danger, the time when the trip will take place if the consumption is still high, effects of their own actions, advice for collective Demand Response, indicators if others (anonymous or not) already took measures of load reduction in order to avoid the trip, and so on.

Only if a 'critical mass' of prosumers participates, can the trip be avoided. Thus avoiding the trip event is critically dependent on common knowledge and synchronised action being established within the natural society of people via the artificial network of devices. The data from the SmartMeters must be transformed into a collective awareness (using the SmartMeters as well to support both visualisation and social networking), and this in turn should be translated into pro-active synchronised action to alleviate the problem.

4.2 Serious Game: Architecture and Design

Designing and implementing a Serious Game based only on demand-side management is not a guaranteed and successful technique, as the user empowerment, inclusion and long-term engagement requires encapsulation and integration of different requirements.

4.2.1 Ostrom's Principles

Ostrom's research proposed that there are eight principles, which are necessary and sufficient conditions for enduring self-organising institutions. Different self-interested and autonomous actors need to self-organise in order to share a common, yet limited resource, in a way so as to avoid its depletion, without even having long-term interests [14].

4.2.2 Different Roles

Users need special guideline and advices to better understand the specific roles they are occupying inside the grid. Users can adopt and have different roles in the SmartGrids according to the goals they want to achieve. For example, in the 'prosumer' role, users make choices about prices, which energy provider to get their electricity from, or selling surplus energy back to the grid. in the 'citizen' role, users may be concerned about the impact of their consumption profile on the environment or may have an interest in setting and meeting policies and regulations. The 'practitioner' may care more for activities like storage or planning local developments, whereas in the 'stakeholder' role, the user might participate in local investment decisions and actions.

4.2.3 Smart Meters

Smart Meters can now have new affordances for the different locations in the 3D environment (pricing and consumption scheme) and the capabilities allocated by the environment.

Smart Meters are like the known meters that are installed on our houses for reading the energy consumption, but their advanced characteristics (process and transmit consumer's information back to energy providers, give feedback to users) make them more functional and useful [13]. If an electrical appliance is connected to a Smart Meter, it can show the real-time energy consumption. Another innovative characteristic is the pricing scheme, which display the different prices according to different time periods. The Smart Meters are not just passive devices which display the energy consumption, but they can serve as agent-based assistants which help players by giving them advices and be adaptive every time to their needs and preferences.

4.2.4 Information Visualisation

Information visualisation for comparative feedback (feedback that compares past energy consumptions) enables users to gain a significant understanding by simply looking at images and figures; data in any form can be visualised and conceived [19]. Comparative feedback should be based on actual energy consumption and it should be provided on a frequent basis (ideally at the end of every month) in order to be effective. Consumers should then be able to have an overview of how much they are charged for using specific electrical appliances in a particular time period [18]. Receiving feedback in a comparative basis helps users to identify their consumption patterns and observe possible changes in their behaviour towards energy use. Studies [6, 8] based on the effectiveness of comparative feedback proved that a maximum 12 % decrease in energy consumption can be achieved. Other findings were that it is more effective than direct feedback and an efficient way for changing users' behaviours and habits towards energy consumption.

4.2.5 Collective Awareness

Collective awareness has been recommended as it supports user's sustainability and adaptability [17]. Collective awareness among members of a community enhances the sense of collective responsibility, whereas if it is missing, the members of the community cannot understand the present situation or occurred changes to their environment. A member of the community may even have a different impression or understanding of the conditions in contrast to others. Moreover, collective awareness enables users to feel part of the community, understand the different rules and norms, and eventually follow them[9]. Collective awareness also ensures that all the members of the community receive a 'fair' share of resources with long-term endurance for the collective.

4.3 Interface Elements

A 3D Serious Game Interface for SmartGrids can provide the required techniques for human inclusion and empowerment. Six different activities can be defined, enabled and supported through the same interface: *i) SmartGrid Representation & Simulation* which is the virtual environment (virtual household with all the electrical appliances connected to Smart Meters) where the user can control and monitor the energy use, *ii) Private & Public Information*, the comparative feedback that users receive regularly (at the end of every month) and it can be provided either on an individual or communal basis, *iii) Assembly*, where the players can discuss and set common goals, define their roles or get informed about the rules and regulations of the game, *iv) Smart Metering* is basically the monitoring agency for the visualisation and display of the data concerning the energy consumption or electricity prices, *v) Rewards & Sanctions*, where the good players can be rewarded and get prizes or benefits (reduced electricity prices), whereas the inappropriate behaviour can be sanctioned and the bad players receive penalties, and finally the *vi) Court Room*, that is a special location in the game where the occurred conflicts can be resolved.

A demand side self-organisation example can empower the players as they are now enabled to control their avatars, take part in a regular, everyday scenario and being incentivised by social capital or rewards, rather than money. When the player gets access to the online virtual world, s/he first gets informed about the particular rules that constitute the game and the different goals s/he needs to accomplish in order to win. Entering the virtual world, s/he has to decide which of the different roles s/he is going to enact. For example, in the 'prosumer' role, the player may have virtual solar panels or wind mill and s/he should make decisions on how to use the energy in a efficient and sustainable way (store energy or sell the surplus back to the grid). Each role has different rules to follow and goals to accomplish. In the *Assembly* room, the different players can vote for protocols, set guidelines to follow in order to win the game and make decisions which concern the rewards, penalties or collective arrangements (consumers may have to decide on the price or consumption scheme that they are going to follow at each specific time period).

The Serious Game defines different kind of rewards: the 'greenest' (best) player can get a prize which can be money, discount on electricity bill or points which will put the user on the first position of the overall ranking. In case of an inappropriate behaviour, the player may receive increased electricity prices or the game may remove some points of his/her score.

During the game, the player can change her/his behaviour accordingly in order to get as many rewards as possible (e.g. prizes and points) and avoid getting penalties (e.g.low overall score). Most of the rewards and penalties can be immediately imposed at any time during the game (e.g., when a challenge is completed or an inappropriate behaviour is detected) whereas, other rewards/penalties should be given at the end of the game, taking under consideration the overall performance of the player. Moreover, players can socialise and communicate by means of private and public chats and set strategies for winning common goals or even encourage each other to achieve individual goals.

Additionally, a personal assistant (agent) can help the player to successfully accomplish her/his goal. Real-time energy consumption and electricity prices can be displayed in public or private boards, enabling users to better understand their behaviour towards energy use. Observing users' behaviour and analysing their energy consumption patterns, favours the users as they can receive advices and guidelines on how to fulfil individual and common goals. Moreover, the players better understand the penalties imposed (e.g., a penalty may be imposed because there is an empty room in the house with the lights on). The users are encouraged to change and modify their behaviour accordingly in order to successfully accomplish a given goal.

5. ETHICAL & PRIVACY ISSUES IN SERIOUS GAMES

SmartGrids place a particular emphasis on the demand-side, which requires both a better understanding of energy consumers' behaviour and getting energy consumers to understand better the effects of their behaviour on the grid. The institutional rules with collective awareness of personal data are augmented to assist users in their different roles.

Given that the players in the Serious Game are humans with responsibilities, beliefs and behaviour with respect to a set of rules, we have encountered ethical issues in three dimensions. Firstly, there is a dimension of fairness, which ensures that all participants in the local micro-grid receive a 'fair' share of the resources. Secondly, there is a dimension of data privacy. Many users are sensitive about revealing their personal details and while they might be willing to trade data for personalised services or even donate data for medical studies, they increasingly do so on their own terms. Thirdly, there is a dimension of sustainability, that the short-term optimisation of utility for the individual is less important than the long-term endurance of the resource for the collective.

We study these problems from, respectively, Ostrom's principles for self-governing institutions and privacy by design contractualism [16]; users are usualy willing to publish their personal data to receive perceived benefits (they may be unaware of the consequences of this action), whereas members of online social networks donate information voluntarily if it is for medical research studies. The above examples highlight the need for a model of privacy based on: *i) Information sensitivity*; users should be informed about their personal data and any risks that may exist of it being exposed, *ii) Information receiver*; users should know who stores and uses their data and *iii) Information usage*; users should be familiarised with the different ways their information is used.

There are some restrictions concerning the user participation in SmartGrids. The majority of users know little about self-organising management, given that the current energy distribution and supply network follows a centralised and controlling model. For an effective grid operation, a high percentage of user participation is needed, whereas the decision-making should be immediate and accurate. Consumers are not always willing to spend money on services or resources that they do not really want or need, and by making them active participants, they have to invest money on amenities with long-term benefits [24]. Users should fully understand their role inside the grid and their future gains and benefits.

Data collection needs to be done within limits and regulations, which have to be set from policy makers. Users should be informed about who is related to their information and how s/he uses it. Personal details should be used only for purposes that are identified and specified from regulations and they should be protected against loss, alteration or unauthorised use. Policies are also needed to ensure that users have the right to ask for their data to be deleted from the database any time they want to. As participants' information can expose their habits, access and control over this information should be limited. Some users might also not be willing to sacrifice their privacy for any personal benefit [13].

6. CURRENT AND FURTHER WORK

In this section we give details of how a Serious Game could be a possible solution to demand-side management of the energy sector, where user inclusivity and empowerment are critical aspects both in short and long terms. We have implemented a dashboard control interface for short term engagement by visualisation of electrical appliances and energy consumption. We are implementing as well a virtual environment interface for long term engagement based on visualising investment decisions. Both cases indicate how Ostrom's principles are encapsulated and integrated through an interface.

6.1 Interface for Short-Term Engagement

In realising this work we have designed and implemented a game-based interface, where the characteristics of user interaction and inclusivity are highlighted. The user needs to accomplish particular tasks based on a simple everyday scenario, and all these works have to be finished within a given time period. The user interacts with the different electrical appliances in the interface (by switching them on and off) and at the same time the total energy consumption is displayed through a graph. To make this interface more interesting and challenging, we have introduced the notion of progression via points. Every time the user accomplishes a task , he is rewarded with some points. These rewards increase the social user behaviour, as a scoreboard is included, showing the ranking of the players based on the points they have collected. Another important characteristic is the feedback. Users receive instant messages according to their energy use and these messages serve as guideline or help to the users. All these different characteristics are presented in Figure 4 and they have been introduced to bridge the engagement gap between the users and the interface.

This interface encapsulates Ostrom's first principle (clearly defined boundaries) enabling the user's access and inclusivity to the game. It could be also extended and be part of the virtual environment interface by representing a particular location/room in the game (SmartMeter). But, to build a life-time relationship for sustainability and investment decisions regarding the energy sector, we need to move on a step towards a visualisation environment.

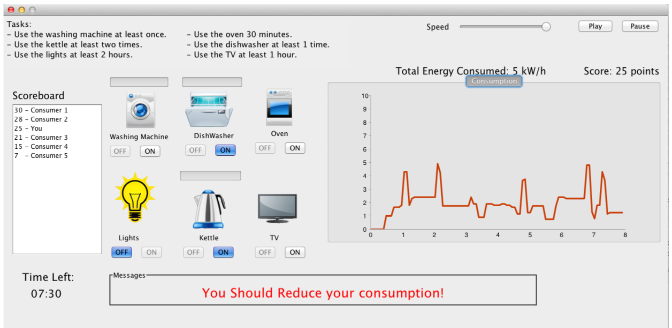

Figure 4: Dashboard Control Interface

6.2 Interface for Long-Term Engagement

Longer-term user engagement and empowerment could be promoted if a virtual world is designed and built based on the concepts of collective awareness and gamification. Gamification is basically the use of game design techniques and mechanics to non-game applications in order to teach, motivate and engage users in a different way. Emphasising on these two aspects, players could feel part of an online virtual community, where sustainability, adaptability and investment decisions are promoted. In this context we plan to extend the concept of Serious Game and include social rules and norms. Our aim is to leverage Ostrom's principles of self-governing electronic institutions, support the different consumer roles inside the game and include Smart Meters and information visualisation. The integration and encapsulation of these requirements by a game - based user - interface will offer users the necessary experience and knowledge for long - term engagement with the new interface and help them gain a better understanding of prices, resource allocation, investment decisions and grid sustainability.

Table 1: Ostrom's Principles encapsulated by a Serious Game

Serious Game	
Ostrom's Principles	*User Participation*
Clearly defined boundaries	Game access
Congruence between appropriation/provision rules and context	Locations supporting comparative feedback for different 'roles'
Collective choice arrangements	Deliberative Assembly location
Monitoring	Smart Meters
Graduated Sanctions	Sanctions and Incentives
Conflict resolution	Court Room location

Table 1 presents the correlation between Ostrom's principles and user participation in a Serious Game for SmartGrids. Principle 1, clearly defined boundaries, represents the player's access to the game. The institution is visualised and represented by a virtual world, where the players need a membership for getting access and occupy an avatar in the game. Principle 2 covers the different locations in the game, which support and visualise the different types of information for different purposes, enabling in this way the players to arrange the rules of the institution in which they take part. The next principle (Principle 3) acts as a specialised decision-making forum for the collective choice arrangements. The monitoring agency for the data streaming (Principle 4) can be implemented by the Smart Meters.

Principle 5, graduated incentives, refers to the rewarding/sanctioning scheme that it is introduced in the game. This scheme is used to reward the successful game players, whereas it imposes penalties in case of inappropriate behaviours. A specialised location (Principle 6) called as 'Court Room' is used for resolving occurred disputes in the game. There are two other principles: no interference from external authorities and systems of systems to ensure that the game cannot be controlled or monitored from the external environment [4].

For the implementation and development of the virtual world infrastructure interface, we need a 3D VW viewer (Imprudence) which provides the interface for promoting and encouraging the user participation. Specifically, this viewer offers different features and characteristics which support various interface customisation choices. The next implementation step is the use of ViXEE (Virtual Institution eXEcution Environment) which is basically the virtual infrastructure-interface, that supports the communication and interactions among different agents.

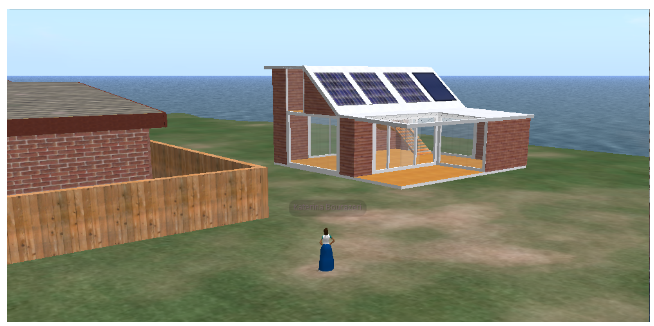

Figure 5: Virtual Environment Interface

6.3 Evaluation

The game evaluation is primarily focused on the effectiveness of the gamification techniques on the energy sector. Further experiments are required in order to verify whether the virtual environment motivates and engages users. Through a rigorous validation process (questionaries and interviews) based on measuring dependent variables (usability, inclusivity, empowerment and users' profiles), we will also be able to understand how it could be used in training people on using electricity effectively and efficiently.

These experiments will be completed with the aid of 'representative' volunteers. The first constraint is how we get volunteers and make them testing qualitative requirements on an experimental design. The training and interaction will be done inside a room or lab, posing some considerations and thoughts regarding the real-life implications of this virtual world [17]. Another constraint would be how we move on from the virtual world to everyday life applications and activities. The evaluation of this interface is critical and it should be done with sufficient large number of participants to be able to collect the effect of collective awareness.

7. CONCLUSIONS

This paper presented a self-organised approach for designing a Serious Game to manage and regulate SmartGrids using a set of social rules and principles. Serious Games could address the demand-side of electricity supply by active participation and user engagement, with particular emphasis to be given on the demand-side self-organisation. Smart Meters through which information is supposed to be pushed, should be perceived as an ICT-enabled technology for both monitoring and reporting of electricity consumption, rather than as a centralised and controlling device for monitoring users' behaviour and actions.

Serious Games, in particular digital games in which Ostrom's principles, support of different user's roles, Smart Meters, information visualisation and collective awareness are integrated and encapsulated by both the interface and the rules of the game, can contribute to the user's empowerment and inclusivity. Serious Games for self-organised electronic institutions could help to build collective ownership and awareness of national infrastructure and improve the efficiency and fairness of its usage.

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