# Steps to Design a Household Energy Game

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## *Abstract*

*Research where gamification is used to influence household energy consumption is an emerging field. This paper reviews the design and effectiveness of ten games that aim to influence household energy consumption and presents a novel gamification approach in which real world activities are implemented in a game design. From the review suggestions for the design of a new game have been identified, such as including real life missions in order to optimize the transfer between the game world and the real world, feedback from monitoring the electricity meter, the presence of a strong storyline, personalized game characters, social interaction, etc. Based on this comparative analysis, the new game 'Powersaver Game' focused on reducing energy consumption has been designed and its prototype is described. In the next stage of iterative design, end-users evaluated the match between in-game scenes and household energy saving activities. This considerate user-centered design process should allow us to build a serious game that is potentially effective in reducing household energy consumption.*

**Keywords:** *Game Design Strategies, Gamification, Energy Consumption, Persuasive Games, Attitude Change, Behavior Change*

## 1. Introduction

Game design can be a valuable strategy for making non-game products, services, or applications, more enjoyable, motivating, and/or engaging the user [6]. The steps in designing a household energy game, which is presented in this paper, are part of a larger research project that will give insight into what the influence of playing in the real world is on sustainable behavior in the long term, and on attitudes towards sustainability. We focus specifically on energy consumption in households by means of electricity and gas usage. The target is to contribute to the stimulation of individual sustainable behavior by studying how gamification can be a positive incentive for people to change their behavior regarding energy use at home. It aims to study whether transfer from gameplay to real life behavior has a long-term character [9]. A situated learning experience is provided if a persuasive game and gamification principles are combined. The player/learner applies his/her knowledge directly to solve real world problems [10]. The inclusion of reality by using gamification principles in a persuasive game is expected to optimize the transfer of knowledge from the game to reality. Gamification research has shown that the integration of serious games into real life could have positive effects on attitude and behavior [9]. As presented in Figure 1, in a normal gamification process gameplay elements are implemented in real world processes to stimulate behavior. In this research project a different and novel approach is chosen. Real world processes in the form of household energy saving activities are implemented in the game design. The aim of this approach is to optimize the transfer between the game world and the real world. When the transfer is optimized the game is expected to be more effective in change of attitude and behavior [12].

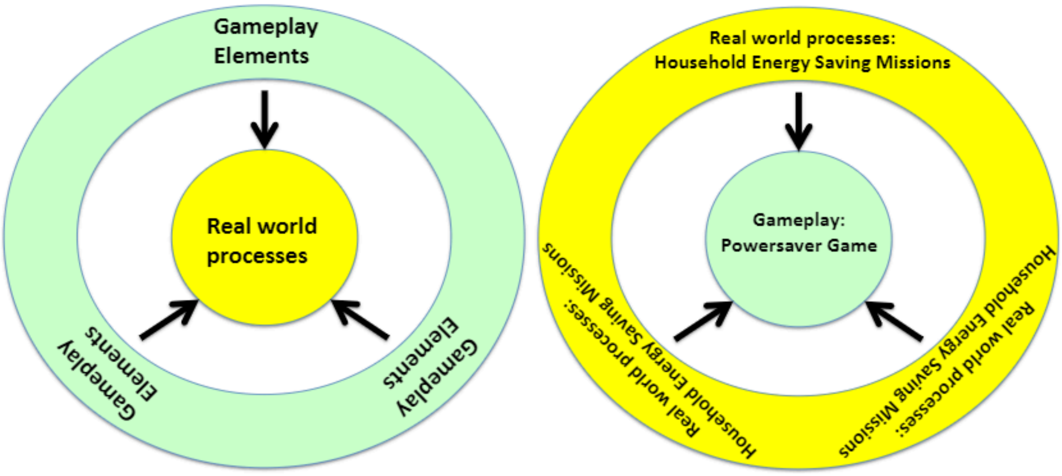


**Figure 1.** Normal (on the left) and Novel Gamification Process (on the right)

For this research project a game was designed that is to be used as a research instrument that will allow us to investigate different factors and that could strengthen the change in attitude and behavior. First, we start with a "media comparison" approach [13] where the effect of the game is contrasted with another medium. During this experiment one group will play our game and a control group will receive the same information in equal time intervals using a dashboard website and results will be compared. The dashboard website has an identical look and feel as the menu page of the game. The form, timing and content of the information the control condition receives are identical as in the game condition, but excludes game elements. Next, in a "value added" approach [13] the effects of the features feedback (minimum versus maximum information), personal relevance (by means of personalized avatars, activities, goals and feedback) and social interaction (by means of competition) on knowledge, attitude and behavior are examined.

For these experiments we take steps to design a game. In Figure 2 the steps to design the household game is presented. First, the design of a game prototype is established (step 1) by analyzing the designs of existing games that have a similar purpose. This is achieved by identifying a number of dimensions in the literature. Also the empirical effects of these games in changing knowledge, behavior and attitude are analyzed. This information is used to develop the design principles that are described in section 3. Next, energy saving activities are formulated that can be carried out in every regular household. Different institutions including non-governmental organizations, energy network administrators and energy companies provide these saving activities. Energy saving missions for the game and energy saving suggestions for the dashboard are abstracted from these saving activities. The energy saving missions are used in the gamification process by incorporating these in the game design. To complete step 1 a game prototype and dashboard prototype are constructed by combining design principles and energy saving missions or suggestions.

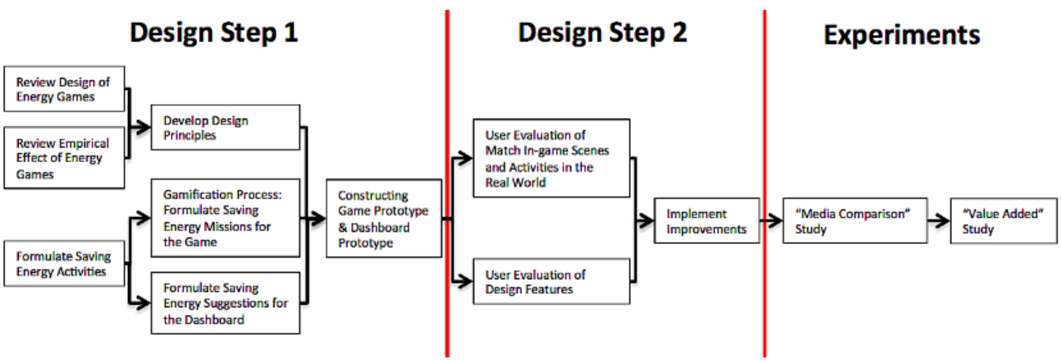


**Figure 2.** First steps to design a household energy game

It is generally recommended that potential users of the game be involved in the development process [5]. Our assumption is that when the analysis (step 1) is done properly and potential users are involved in the design process (step 2), then this considerate user-centered game design will lead to a high quality game that is effective in reducing household energy consumption. The outcome of the user evaluation 'match in-game scenes and activities in the real world' of step 2 is part of the gamification process and described in this paper (section 4). The user evaluation of design features of the complete system will be addressed in a future paper. After these steps we will start the experiments. The first experiment is a "media comparison" study and the second a "value added" study [13].

We will first identify games that have similar, or at least partially similar, goals to the future game developed here (section 2). The design of these games is analyzed with the dimensions/characteristics identified. The optimal implementation of characteristics, and what might be lacking, will become clear from the considerate analysis. Also the effect of the games is analyzed to conclude if the designs are sufficiently effective. Based on this, suggestions are made (section 3) for the design of the game consistent with the research objectives and description of our prototype is presented. The match between activities in the real world and game world of this prototype is evaluated with empirical data (section 4). Finally, we draw conclusions and discuss how we will continue our research with the Powersaver Game (section 5).

The constructing of the dashboard for the control condition in the "media comparison" study is not discussed in this paper.

## 2. Overview of method to analyze energy games

In this section the goals for the new designed game are presented. Next, similar energy games are analyzed on their game characteristics. The results of this study are input for constructing a game prototype (section 3).

### 2.1 Goals

We have formulated six goals based on the requirements of the design of the game (Table 1). The first goal is that the game makes players aware of sustainability issues concerning energy use at home. The game raises awareness. The second goal is the transfer of information about energy consumption so that players acquire more knowledge. The third goal is that players will be influenced by the game to change their behavior concerning energy consumption in real life. The fourth goal is that behavior in real life is integrated into the game by monitoring behavior in real life and using this information in the game progression. The fifth goal is that the game is played over a relatively long period of time and has several sessions. The sixth and final goal is that the game has a compelling and complex storyline that is able to engage players. A storyline in a game can be engaging because it stimulates our emotions [15]. A complex storyline includes a setting where game characters have to achieve goals and face multiple obstacles in reaching these goals [19].

**Table 1.** Goals Game Design

| | |
|---|---|
| 1. | Awareness Sustainable Energy Use at Home |
| 2. | Information Transfer Energy Consumption |
| 3. | Influencing Energy Consumption at Home |
| 4. | Integrating Real Life Behavior |
| 5. | Playing a Longer Period |
| 6. | Compelling and Complex Storyline |

### 2.2 Energy games

Our game design is focused on energy use at home, specifically where personal behavior is involved. Games that also have this focus were chosen based on the above six goals. In February 2015, searches were performed in scientific databases and with the aid of public search engines. In these databases eight games were found that had been used as a research instrument with similarities to our research. These eight games are analyzed in this paper. The output of public search engines also suggested many games that are used for education and entertainment (but not for research) purposes. Unfortunately, only two additional games (Joulebug and 2020Energy) are interesting to analyze because they have some similarities with our goals. Other games that came out of the search are not useful because they do not have a connection with real life energy consumption behavior and/or are too simple. The ten selected games are presented in the Table 2.

### *2.3 Characteristics of game design evaluation*

Nineteen characteristics that are inspired by Prensky [15], Adams [1] and Schell [18] are distinguished to evaluate the ten games. For this evaluation we used the publiced papers, additional documents and corresponding websites. The first author analysed whether these characteristics were present and to what extent they applied. These characteristics are mentioned in Table 2. The characteristics are clustered into five topics. The first topic is identification. A game is introduced by mentioning four general characteristics: (1) the year the game was released, (2) the research group/owner, (3) the purpose of the game (research, education or entertainment) and (4) the profile of the players. The second topic is Gameplay. The game itself is described by mentioning (5) the description of the game type, (6) quality of the storyline, (7) the levels and progression (chronologic stages in difficulty) and (8) the representation of game characters. The third topic is Game Design. The presentation of the game and features are discussed by describing (9) the world (real life and/or in-game) where missions are accomplished, (10) the quantity of missions, (11) the possibility to personalize, (12) feedback and rewards, (13) competition (high scores by oneself and/or competing against other players), (14) the quality of the graphic design, (15) real world effect (effect of behavior in the real world on progression in the game), (16) monitoring the electricity meter and (17) the duration of the game. The fourth topic is (18) the Technical Architecture that explains the technical design of the system. The fifth and final topic is Measurements. In this topic the kind of measurements that are used (19) is mentioned.

**Table 2.** Overview Ten Energy Games

| Topic | Game / Characteristic | 1 The Power House [2] | 2 Power Agent [3][9] | 3 EcoIsland [11] | 4 Power Explorer [4][10] | 5 Agents Against Power Waste [20] |
|---|---|---|---|---|---|---|
| Identification | 1 Year | 2006 | 2007 | 2008 | 2008 | 2010 |
| | 2 Research group / Owner | Bang et al. | Bang et al. | Kimura et al. | Bang et al. | Svahn, M. |
| | 3 Purpose | Research | Research | Research | Research | Research |
| | 4 Players profile | Teenagers | Teenagers in households | Households incl. teenagers | Teenagers in households | Households incl. teenagers |
| Gameplay | 5 Game type | Simulation & Role-playing | Adventure & Role-playing | FarmVille like | Multiplayer | Adventure & Role-playing |
| | 6 Storyline* | + | + | -- | + | + |
| | 7 Levels & Progress* | + | + | -- | ++ | ? |
| | 8 Game Characters * | + | + | + | + | -- |
| Game Design | 9 Mission world | In-game | Real life | Real life | Real life | Real life |
| | 10 Mission quantity | ? | 7 | ? | 2 duels | ? |
| | 11 Personification / Personalization | No | No | Yes | No | No |
| | 12 Feedback and Rewards** | Combi. | Combi. | Combi. | Combi. | ? |
| | 13 Competition (Oneself / Other) | O/O | O/O | O/O | O/O | O/O |
| | 14 Graphic Design* | - | + | - | ++ | - |
| | 15 Real world effect* | -- | ++ | ++ | ++ | ++ |
| | 16 Monitoring Electricity meter | No | Yes | Yes | Yes | Yes |
| | 17 Duration | 1 Session | 1W | 3W | 1W | 4W |
| | 18 Technical Architecture* | - | ++ | + | ++ | ++ |
| Measurements | 19 Measurements: | | | | | |
| | - Knowledge | ? | Yes | No | Yes | Yes |
| | - Attitude | Yes | Yes | Yes | Yes | Yes |
| | - Energy usage | No | Yes | Yes | Yes | Yes |
| | - Engagement | Yes | Yes | No | Yes | Yes |

| Topic | Game / Characteristic | 6 EnergyLife [7][8] | 7 Joulebug | 8 Power House [16][17] | 9 2020 Energy | 10 Energy Chickens [14] |
|---|---|---|---|---|---|---|
| Identification | 1 Year | 2011 | 2011 | 2011 | 2012 | 2014 |
| | 2 Research group / Owner | Gamberine et al. | Joulebug | Reeves et al. | ENERGY-BITS | Orlanda et al. |
| | 3 Purpose | Research | Entertainment | Research | Education | Research |
| | 4 Players profile | Adults in households | Trendy young adults | Adults in households | Teenagers | Office workers |
| Gameplay | 5 Game type | Eco-feedback | Social mobile | Multiplayer | Simulation & Role-playing | FarmVille like |
| | 6 Storyline* | -- | -- | + | + | -- |
| | 7 Levels & Progress* | ++ | -- | + | - | - |
| | 8 Game Characters * | -- | -- | + | + | + |
| Game Design | 9 Mission world | Real life | Real life | In-game & Real life | In-game | Real life |
| | 10 Mission quantity | ? | ? | 10 sessions | 9 | ? |
| | 11 Personification / Personalization | Yes | No | No | No | No |
| | 12 Feedback and Rewards** | Combi. | Combi. | Combi. | Points & Ach. | Combi. |
| | 13 Competition (Oneself / Other) | O/O | O/O | O/O | Oneself | O/O |
| | 14 Graphic Design* | + | ++ | ++ | ++ | + |
| | 15 Real world effect* | ++ | ++ | - | -- | ++ |
| | 16 Monitoring Electricity meter | Yes | Yes | Yes | No | Yes |
| | 17 Duration | 16W | Infinite | 2,5W | 1 Session | 27W |
| | 18 Technical Architecture* | ++ | ++ | + | - | ++ |
| Measurements | 19 Measurements: | | | | | |
| | - Knowledge | Yes | No | Yes | Yes | Yes |
| | - Attitude | Yes | No | ? | Yes | Yes |
| | - Energy usage | Yes | Yes | Yes | Yes | Yes |
| | - Engagement | Yes | No | ? | Yes | Yes |

* --/-/+/++

** Points, Badges/Achievements, Energy use/savings or a Combination (Combi.)

### 2.4 Meeting the goals

First, we will indicate to what extent the analyzed games met the goals that are described in paragraph 2.1, the outcome of this calculation is a percentage of the goals that are met. Most goals are incorporated based on the high scores (Table 3), only the games The Power House and 2020Energy meet fifty percent of the goals. Other games do meet most of the goals. So we can conclude that most games have similarities with our new game design. The first goal is to make players aware of sustainability issues concerning energy use at home. To some degree almost all analyzed games, except Energy Chickens, do this. The games EcoIsland, Joulebug and 2020Energy also focus on energy use out of home. Energy Chickens is played in a work environment instead of a home but it is very likely that these players will also be more aware of energy use at home. The second goal is the transfer of information about energy consumption so that players acquire more knowledge. All analyzed games do this. The games Joulebug and 2020Energy also focus on other sustainability issues. The third goal is that players will be influenced by the game to change their behavior concerning energy consumption in real life. All analyzed games do this more or less. This effect seems to be more likely when the electricity meter is part of the technical architecture. Because of this the games The Power House and 2020Energy will only have indirect influence, as the energy


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usage is not measured. The games The Power House and 2020Energy do not meet the fourth goal because the electricity meter is not connected to the game, and do not meet the fifth goal that the game is played over a long period of time and has several sessions. The sixth goal is to have a compelling and complex storyline. Six games have a storyline, but unfortunately it is in all cases a very simple one. None of the games has strong storylines. Storylines appears to be an aspect we should take into account and integrate in our game.

**Table 3.** Meeting the Goals Game Design

| Game / Goal | 1 The Power House [2] | 2 Power Agent [3][9] | 3 EcoIsland [11] | 4 Power Explorer [4][10] | 5 Agents Against Power Waste [20] |
|---|---|---|---|---|---|
| 1. Awareness Sustainable Energy Use at Home | + | + | + | + | + |
| 2. Information Transfer Energy Consumption | + | + | + | + | + |
| 3. Influencing Energy Consumption at Home | + | + | + | + | + |
| 4. Integrating Real Life Behavior | - | + | + | + | + |
| 5. Playing a Longer Period | - | + | + | + | + |
| 6. Compelling and Complex Storyline | - | - | - | - | - |
| % Attained | 50% | 83% | 83% | 83% | 83% |
| **Game / Goal** | **6 EnergyLife [7][8]** | **7 Joulebug** | **8 Power House [16][17]** | **9 2020 Energy** | **10 Energy Chickens [14]** |
| 1. Awareness Sustainable Energy Use at Home | + | + | + | + | _ |
| 2. Information Transfer Energy Consumption | + | + | + | + | + |
| 3. Influencing Energy Consumption at Home | + | + | + | + | + |
| 4. Integrating Real Life Behavior | + | + | + | - | + |
| 5. Playing a Longer Period | + | + | + | - | + |
| 6. Compelling and Complex Storyline | - | - | - | - | - |
| % Attained | 83% | 83% | 83% | 50% | 67% |

## *2.5 Evaluation of the implementation of game characteristics*

The ten games that are selected have been analyzed and compared to each other by means of these nineteen characteristics. An overview of the results of this analysis is presented in Table 2. In the order of the five topics, the a-priori best implementations of characteristics and what is overall lacking are discussed. At the same time suggestions for the new design are made.

**Topic 1. Identification** Characteristics Year (Char 1), Research group/Owner (Char 2) and Purpose (Char 3) are not discussed because they are only used to identify games. It is interesting to look closer at Player's profile (Char 4). In six games the game is played in family households, which include teenagers. There are good arguments to use family households as a study population. Family members all consume energy that can only be measured from an electricity meter, so it is reasonable and preferable that the whole family is involved in playing.

**Topic 2. Gameplay** Six different game types (Char 5) are mentioned. Two games are Simulation & Role-playing games, two games are Adventure & Role-playing games, two games are FarmVille like games and two games are Multiplayer games. EnergyLife is the only Eco-feedback game and Joulebug is the only Social mobile game. Implementing simulations can help players to prepare for real life missions. Role-playing can engage players more and adventure elements can be used for the storyline. Altogether, the games mainly focus on providing feedback on energy consumption. There are no games with a compelling and complex storyline (Char 6). In general the games are not story-focused and miss the opportunity to enhance gameplay [18]. The games Power Explorer and EnergyLife have the best level and progression structure (Char 7). The strength of the game Power Explorer is the combination of normal gameplay and duels. EnergyLife has three levels with different activities. None of the games has levels that become more difficult during playing, and no game has the alignment of a compelling storyline and difficulty in playing. For our game it is preferable that a storyline will be implemented and missions become more complex when progression in the game is made. In seven games, game characters (Char 8) are used in the design. In the games The Power House, EcoIsland and Powerhouse the characters are family members that have some similarities with the characteristics of the players. Only in EcoIsland it is possible to "personalize" the player's avatar. This feature should be implemented in the design of our game because it establishes a stronger connection between the game and reality [18].

**Topic 3. Game Design** Eight games have real life (Char 9) energy saving missions. The game Power House has a strong combination by using both real life and in-game missions. It is preferable that in the design our game missions have to be carried out in real life. Using in-game missions to prepare players for real life missions is an option that should be considered. From six games we have no information about the quantity of missions (Char 10) available. The game Power House has, with ten missions, the most. In the games EcoIsland and EnergyLife personalization (Char 11) is to some extent possible. In EcoIsland the avatars can be personalized, and in EnergyLife a player can add two electrical devices to the five that are standard monitored. The personalization of avatars and the addition of electrical appliances in the game are preferable, because it can have a positive influence on the involvement of the players. Seven of the ten games provide extensive feedback (Char 12) by means of points, badges/achievements and overviews of energy used or saved. All items should be implemented in our game design. In nine games players compete (Char 13) against themselves and others. Both should be implemented in our game. Only in the game 2020Energy do players not compete against each other. Four games have high quality graphics (Char 14). The game Power House has the best graphics and can be used as an example for the development of the game for our research project. In seven games the player's behavior in the real world has a very strong effect on the game (Char 15). In our game it should be strong because real life missions will be implemented. In eight games the energy consumption is monitored (Char 16). This should be implemented in our game. Information that is obtained from continuously monitoring the energy consumption can be used to make progression in the gameplay. In the games EnergyLife and Energy Chickens electrical devices are monitored separately. This could be considered for implementation in our game if more specific feedback from individual appliances has to be provided. The duration of the games (Char 17) varies between a session to twenty-seven weeks. Four games are played for a month or more. Because we want to look at the long-term effects on behavior and attitude after playing the game it is plausible that the duration of our game should be extensive.

**Topic 4. Technical Architecture** (Char 18) In six games the Technical Architecture is very advanced. The energy consumption is monitored and sometimes directly used in the game. For the game design of our project it is preferable that a real time connection between the electricity meter and game server is accomplished by using a datalogger with an Internet connection that is connected to the electricity meter in a household that has a WiFi network. The data of energy consumption will be sent to a database of a server. The option to cooperate with a network operator instead of using a datalogger is not recommended because the data transfer can be delayed. It is preferable that the game is basically an Internet page that is uploaded by a device (e.g. tablet) when the player logs in via an Internet browser.

**Topic 5. Measurements** (Char 19) Knowledge, Attitude and Engagement are measured by means of questionnaires outside the gameplay. These questionnaires should be filled in before and after playing. Knowledge is also often measured with in-game quizzes and engagement can be measured by monitoring player's behavior during playing. These two options should be considered in our game design. Energy usage is measured by monitoring the energy meter. To set a good baseline for giving feedback about average energy consumption during playing, the energy consumption should be monitored before the game starts.

In the next section we detailed the effect of the games that we found.

### 2.6 Empirical Effect of Energy Games

The next step is to evaluate the effects each game had on acquired knowledge, attitude towards saving energy, actual energy usage and engagement with respect to continuing playing the game. Insight in these effects can possibly give direction for implementation of design features in our game. Because the reported effects are all positive (Table 4), all design suggestions described in paragraph 2.5 can possibly be implemented. It is not possible to give exact outcomes of the effects because in most papers they are not fully reported, though it is sufficient to draw preliminary conclusions. Unfortunately there is no information available from the games The Power House, Joulebug and 2020 Energy. Though, all reported effects are positive the game designs can be improved because not all topics are fully/optimal implemented and not all goals are met. Behavior change can sufficiently be improved, certainly when all topics and goals are met in a new game design. A prototype of a new game that met all topics and goals is presented in the next section.

**Table 4.** Reported Effects of Energy Games

| **Game** / **Empirical Effect** | 1 The Power House [2] | 2 Power Agent [3][9] | 3 EcoIsland [11] | 4 Power Explorer [4][10] | 5 Agents Against Power Waste [20] |
|---|---|---|---|---|---|
| Knowledge | N/A* | Positive | N/A | Positive | Positive |
| Attitude | N/A | Positive | Positive | Positive | Positive |
| Energy usage | N/A | Positive | Positive | Positive | Positive |
| Engagement | N/A | Positive | N/A | Positive | Positive |
| **Game** / **Empirical Effect** | 6 EnergyLife [7][8] | 7 Joulebug | 8 Power House [16][17] | 9 2020 Energy | 10 Energy Chickens [14] |
| Knowledge | Positive | N/A | Positive | N/A | Positive |
| Attitude | Positive | N/A | N/A | N/A | Positive |
| Energy usage | Positive | N/A | Positive | N/A | Positive |
| Engagement | Positive | N/A | N/A | N/A | Positive |

* Not Available

## 3. Constructing Game Prototype Powersaver Game

### 3.1 Required design features

From paragraph 2.5 and Table 2 we derive the following recommendations on design features to be implemented in the design of our game. Players should be all members of a household and play together. The game should have a compelling storyline and players have to accomplish real life missions that are provided by the game. Knowledge should be provided by questions in in-game quizzes. Missions should become more difficult over time and have a connection with the development of the storyline. The duration of a mission should depend on its intensiveness and will vary between one to three days. Depending on the quantity of missions the game should take at least more than a month to play, because we want to look at the long term effects. For that reason, we assume that the game should take a considerable length of time. The game characters/avatars should have similarities with the players (by personalization). The world/setting of the game should have similarities with a household. Therefore specific devices of households should be present in the game world. Feedback should be provided by means of earned points, badges/achievements and overviews of energy used and saved. Players should be stimulated to achieve high scores and should be in competition with other households. The game should provide readings from the electricity meter and/or if technically possible readings from household appliances.

### 3.2 Design of Powersaver Game

In order of the five topics, we describe the design of the prototype of our game ‘Powersaver Game’. The game has a storyline where avatars of the actual players face appliances in a bad situation in different rooms of a country house. By doing real life energy saving activities in a household corresponding to the in-game appliances the players make progression. All members of a household are involved playing this game for almost eight weeks at home. Every two days energy saving activities will be provided by the game and have to be carried out in real life. Results in energy savings that is provided by a datalogger connected to the smart energy meter are presented as feedback in the game.

**Topic 1**. **Identification** The game will be played in a household whereof in principle the whole family is involved (Char 4).

**Topic 2**. **Gameplay** It is an Eco-feedback, Multiplayer, Roleplaying and Point & Click Adventure game (Char 5). The game starts with an introduction of the story (Char 6). A family arrives at a dilapidated country house where something terrible has happened. The house used to be a peaceful place but that has changed dramatically caused by a failed experiment of a professor. The family enters the main hall of the house that contains several doors (Figure 3). Behind each door a room is situated where a game character in the form of a confused electrical device is placed. In the game 8 different scenes occur, each triggering a mission that had to do with specific energy saving activities such as efficient use of lighting and chargers (Table 5). A ferret (former pet of the professor) called Kyoto guides the family in the game. Every week the family is asked to enter a preselected room. Before the door opens a quiz has to be played. A quiz contains questions that will transfer knowledge about saving energy as well as prepare players for the missions that are occurring in that specific room. When the family enters the room a character in the form of a device that is in a confused state is shown (Figure 4 left). The family has to accomplish two missions to help the device character to get in a normal state (Figure 4 right). During the game the missions are getting more difficult (Char 7). The principle is that each new mission will take more effort to do than the previous one. Avatars of the family members are the central characters of the game (Char 8) (Figure 5).

**Table 5.** Scenes and Mission Goals

| Scenes | Mission Goals |
|---|---|
| 1. The ferret is captured in the wires of angry laps in the living room. | Efficient use of lightning and chargers |
| 2. A stressed computer in the study room. | Efficient use of computer devices |
| 3. An overheated central heater in the bathroom. | Efficient use of heating and hot water |
| 4. A sick plant in the bedroom. | Efficient use of daylight and fresh air |
| 5. An exhausted television in the television room. | Efficient use of the television |
| 6. A sweating clothing dryer and washing machine with foam in the mouth in the washing room. | Efficient washing of clothing |
| 7. A freezer with flu and a refrigerator with a cold in the scullery. | Efficient cooling |
| 8. A wild blowing kitchen hood, overflowing dishwasher and fire-breathing oven in the kitchen. | Efficient cooking |

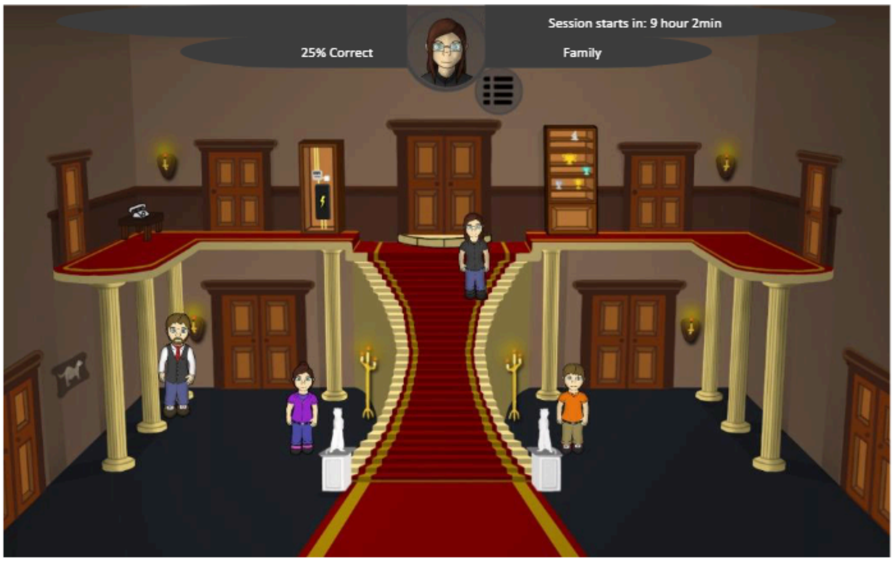


**Figure 3.** The Main Hall

**Figure 4.** Scenes Living Room; Bad State (on the left) and Normal State (on the right)

**Figure 5.** Avatars

**Topic 3. Game Design** As said, in total there are eight scenes in eight rooms of the professor's house. There are fifty energy saving activities that are incorporated in thirteen missions over the eight scenes (Table 5). All missions (e.g. washing clothes on low temperatures) take place in the real world (Char 9). It will take two to three days to complete a mission. The missions are developed by the use of general energy saving measures. As mentioned in Topic 2 to improve the situation of the electrical appliance(s) in the scenes, multiple energy saving activities have to be carried out. Another example is presented in Figure 6. The freezer and refrigerator are sick and can be cured when the following energy saving activities concerning cooling are carried out:

- Turn the temperature of the refrigerator on 6 degrees (number 2 or 3).
- Do not keep products in the refrigerator that can be preserved outside it.
- Turn the temperature of the freezer on minus 18 degrees.
- Clean the rubber seal of the door of the refrigerator and freezer.
- Before you put warm food in the refrigerator let it cool down.
- Let frozen food melt in the refrigerator.
- Place the refrigerator minimal 10 centimeter of the wall.

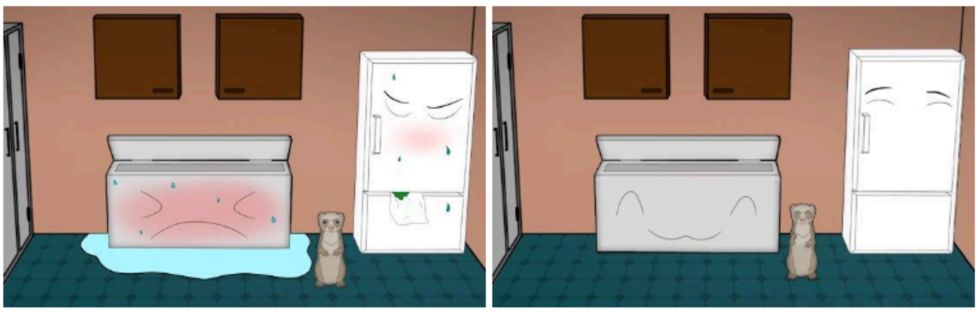

**Figure 6.** Scenes Scullery; Bad State (on the left) and Normal State (on the right)

In each room there are one or more electrical appliances. In total there are eleven electrical appliances and one plant (Figure 7). The objects on the left side are in a bad state and the same objects are in a normal state on the right side.

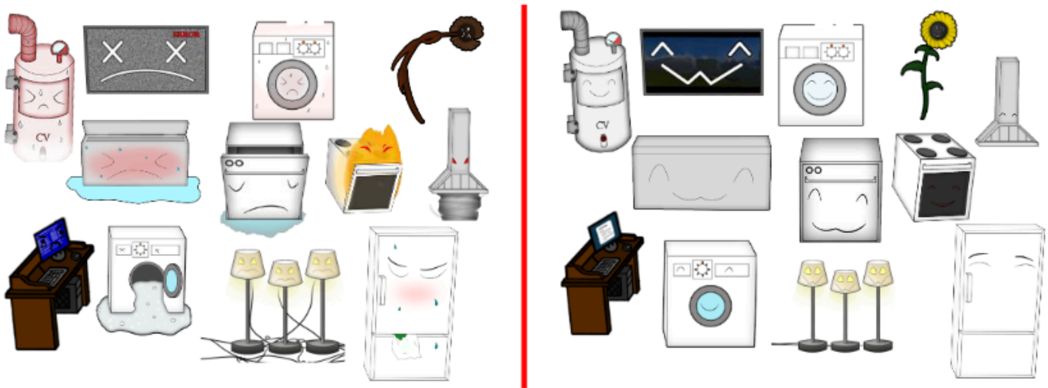

**Figure 7.** In-game objects; Bad State (on the left) and Normal State (on the right)

To change each object from a bad state to a normal state the player has to carry out energy saving activities that are specific for each object. If there are more objects in one scene the player has to carry out several energy saving missions. The game also has (eight) quizzes and an end-battle (Char 10). The family composition in the game is personalized to the household (Char 11). In the prototype it is not possible to add specific devices from the household, though all general household devices are incorporated in the game. The player is getting feedback during playing (Char 12) (Figure 8). A mission always ends after two days. At that moment the following results/feedback is presented:

- Savings
- Overall view of energy use
- Badge of the device character

The energy use and savings are displayed in kWh and money. Also the savings per year is provided. A graph is used to give the player an overview of the energy use and a meter is developed to stimulate the energy saving behavior. In future versions of Powersaver Game players are stimulated to save specific percentages of energy corresponding to a mission. We assume that when missions are carried out the average energy consumption will drop accordingly. The achievement of a completed mission is displayed with a badge of the happy device character corresponding with that mission. The result of the quizzes, which is played before a mission starts, is shown in a bar when a quiz has ended. There is no competition (Char 13) with other households implemented in this prototype. In future versions this will be added. The quality of the graphic design (Char 14) seems to be adequate and the navigation by the player is done by point and click on the screen. The player's behavior in the real world has a very strong effect on the game (Char 15), because real life behavior influences progress by means of completing missions and feedback of real life energy consumption that is monitored (Char 16) and presented continuously. The total period of playing the game is seven and a half weeks (Char 17) because each mission takes two days. In this period all saving activities can be carried out in a regular household.

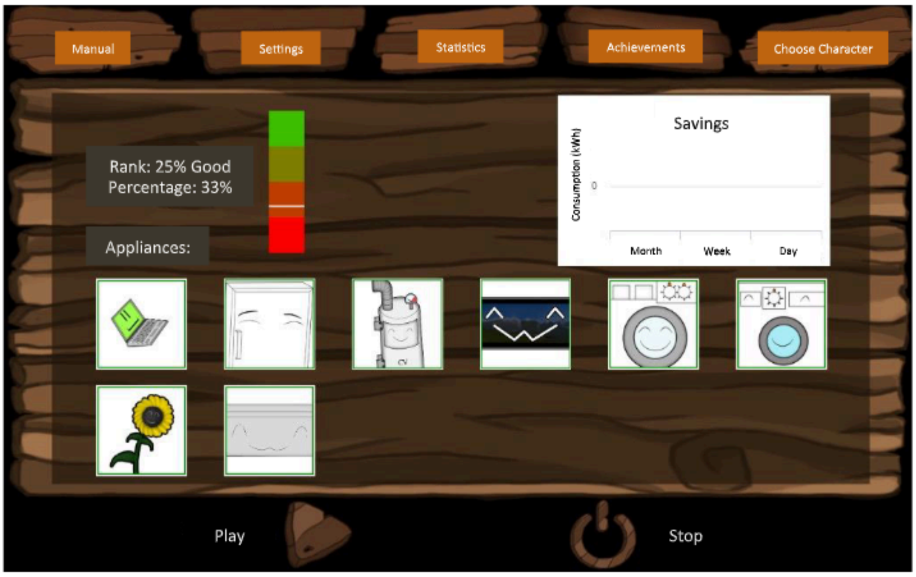


**Figure 8.** Feedback Screen

**Topic 4. Technical Architecture** An overview of the proposed technical architecture is shown in Figure 9 (Char 18). A real time connection between the electricity meter and individual appliances and game server is accomplished by dataloggers with an Internet connection provided by BeNext, a partner of the research project. The households have a WiFi network. The data of energy consumption will be sent to a database of a server at Utrecht University. The game is an Internet page that is uploaded by a device (e.g. tablet) when the player logs in via its Internet browser.

**Topic 5. Measurements** Energy consumption is monitored a month before the game starts to set a good baseline of average energy consumption. All four effects of playing the game are measured (Char 19). Knowledge will be measured by using questionnaires before and after playing and the scores of quizzes in the game. Attitude will also be measured by using questionnaires before and after playing. Energy usage will constantly be monitored from the energy meter. Engagement will be measured by using questionnaires before and after playing, by monitoring player's behavior during playing and monitoring how often the player logs in and what he/she is exactly doing for how long.

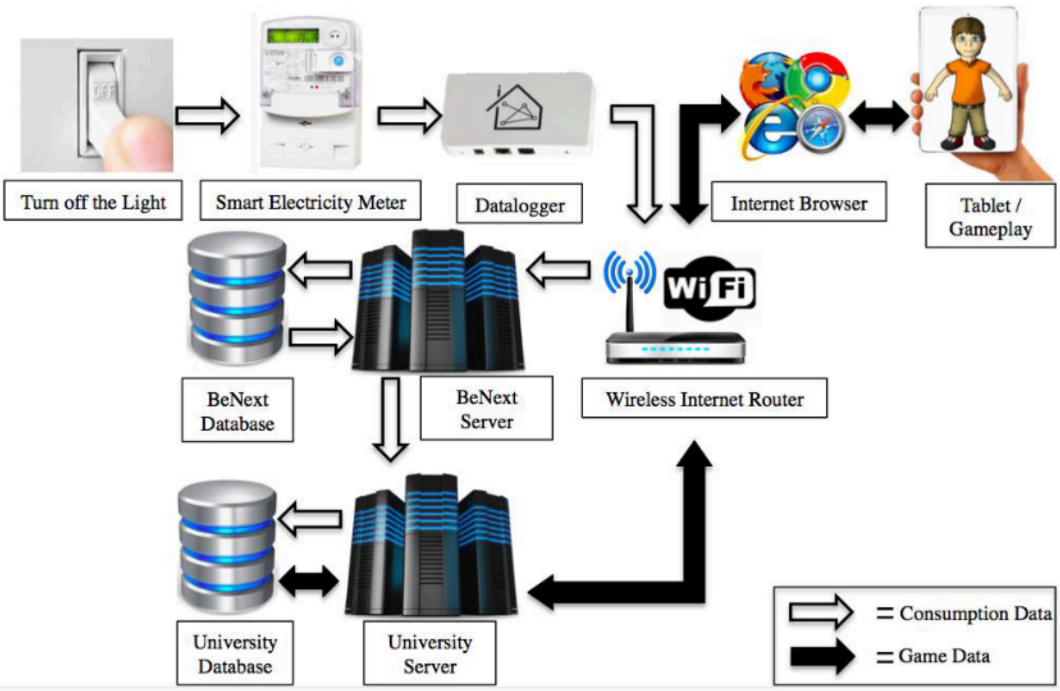


**Figure 9.** Technical Architecture

## 4. User Evaluation Match Scenes

As mentioned in the Introduction section, the gamification process that is used is expected to optimize the transfer by implementing real word processes in a game design. In this paragraph a pilot study is presented that evaluates the implementation of household energy saving activities in the game. In a study four potential players of *Powersaver Game* have evaluated the perceived match between in-game scenes and activities in the real world. The aim of this study is to measure the potential transfer between the game world (eight scenes and twelve cartoons of electrical appliances) and the real world (fifty energy saving activities). The participants were instructed to read a text about the situation of an in-game scene and how well this situation can be solved by carry out energy saving activities in a household, for instance missions involving cooling activities that are explained in Section 3.2 Topic 3. First the situation is explained; "In the scullery a freezer with flu and a refrigerator with a cold have to be cured by carry out energy saving activities concerning cooling." Next the participant is instructed to indicate on a 5-point scale how well an activity in real life relates with changing the situation in the game. For instance; "Set the temperature of the refrigerator on 6 degrees (position 2 or 3) and the freezer on minus 18 degrees." So after reading the texts, participants rated the strength of the match between the situation of the electrical appliances and the energy saving activities that have to be carried out. They were also invited to give comments in writing to make clear what possibly could be improved. The perceived match between the eight in-game scenes and the fifty activities in the real world has an average score of 3.9 on a 5-point scale. The standard deviation is 1.3, suggesting that it is still possible to improvements. In order to get an impression of the reliability of the rating method, we calculated the correlation between the ratings of the four participants. Although the average correlation between the ratings of the four participants was not that high (.48, $p<.05$), when one rater was deleted the average correlation increased to an acceptable level (.61, $p<.05$).

To change each object from a bad state to a normal state the player has to carry out energy saving activities that are specific for each object. If there are more objects in one scene the player has to carry out several energy saving missions. Because of this, both the match between energy saving activities and the twelve electrical appliances, and the match between energy saving activities and the eight scenes, which can contain more electrical appliances, can be evaluated. In Table 6 the match between the electrical appliances and missions and in Table 7 the match between scenes and missions are presented. The scores of the first five scenes and objects are the same because each of these scenes has only one object.

**Table 6.** Match Appliances

| Match Appliances | Mean | Std. Deviation |
|---|---|---|
| 1. Lamps | 3,0 | 1,3 |
| 2. Computer | 4,1 | 1,0 |
| 3. Central Heating | 4,3 | 1,0 |
| 4. Plant | 3,0 | 1,7 |
| 5. Television | 3,6 | 1,3 |
| 6. Clothing Dryer | 3,1 | 1,5 |
| 7. Washing Machine | 3,3 | 1,5 |
| 8. Freezer | 4,8 | 0,5 |
| 9. Refrigerator | 4,5 | 0,9 |
| 10. Kitchen Hood | 4,7 | 0,5 |
| 11. Dishwasher | 4,4 | 0,7 |
| 12. Oven | 3,1 | 1,7 |

**Table7**. Match Scenes

| Match Scenes | Mean | Std. Deviation |
|---|---|---|
| 1. The ferret is captured in the wires of angry laps in the living room. | 3,0 | 1,3 |
| 2. A stressed computer in the study room. | 4,1 | 1,0 |
| 3. An overheated central heater in the bathroom. | 4,3 | 1,0 |
| 4. A sick plant in the bedroom. | 3,0 | 1,7 |
| 5. An exhausted television in the television room. | 3,6 | 1,3 |


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| | | |
|---|---|---|
| 6. A sweating clothing dryer and washing machine with foam in the mouth in the washing room. | 3,6 | 1,5 |
| 7. A freezer with flu and a refrigerator with a cold in the scullery. | 4,5 | 0,8 |
| 8. A wild blowing kitchen hood, overflowing dishwasher and fire-breathing oven in the kitchen. | 4,0 | 1,3 |

The scores below four indicate that improvements can be made. Based on comments of the participants, energy saving activities, scenes and objects could be changed. In total 15 energy saving activities from the scenes 1, 4, 5, 6 and 8 are adjusted (as indicated in Table 6 and 7). The formulations of some activities were not explicit enough and are rewritten. Activities that are repetitions of earlier activities have been deleted, because players can reread all information at any moment in the game. During some activities players had to count items, like lamps and windows. Because these counts are not incorporated in the gameplay these activities are deleted. Activities for washing clothes are combined in one washing activity. The artwork of scene 4 (the plant) is improved and one scene is added. This new scene is placed after scene 6 and is called 'tea time'. The participants commented about the mismatch between scene 6 and some energy saving activities that had nothing to do with washing. In the new scene the family is asked to make tea in a sustainable way and drink it in the tearoom. While drinking tea they have to evaluate the gameplay till so far. With these improvements we are in a good position to enhance the match between in-game scenes and activities in the real world. This should have a positive effect on the transfer between the game world and the real world, which can make the game more effective [12].

## 5. Conclusion and Discussion

In this paper we presented our steps to design the household energy game Powersaver Game that will be used for a larger research project that studies how a gamification can be a positive incentive for people to change their behavior regarding energy use at home. Our considerate user-centered game design methodology includes two design steps to develop a persuasive game. In step 1 design principles are formulated to design a game prototype and in step 2 potential users are involved to evaluate this prototype. See Figure 2. We assume that following these steps will lead to a high quality persuasive game that is effective in influencing behavior. This approach has an iterative character because the prototype design is adjusted several times before a final design can be used for experiments. In step 1 the prototype is developed based on input from literature and in step 2 adjustments are made based on feedback of potential players.

More specific in the first step we have formulated goals based on the requirements of the design of the game. The goals are generated effects (awareness, information transfer and behavior) and characteristics (integration in real life, duration, storyline). The design features and empirical effects of games that met these goals are reviewed and 17 design features have been recommended for the game prototype. Also, household energy saving missions have been formulated in this step. Based on a novel gamification process these missions have been incorporated in a prototype game design. Implementing real world processes in a game design is still an emerging field in gamification research. We are convinced that this is very important because it probably optimizes the transfer of knowledge between the game world and the real world which can lead to change in attitude and behavior.

In the first part of step 2 potential players are involved to evaluate the implementation of household energy saving missions in the game, because we strive to develop a game that is based on user-centered design principles. As a result of this part of step 2 improvements in activities, scenes and objects in the prototype game design are made which resulted in a better match for transfer knowledge. Still the presented prototype is not yet fully user-centered. In the next part of step 2 potential players will be involved to evaluate the complete design by judging the storyline, missions, quizzes, artwork and elements of the game structure like gameplay, feedback and reward systems, personal relevance and competition. By taking these steps we will succeed in developing a game design/instrument to conduct a successful "media comparison" study and "value added" study. Though it was equally important that the game developers have skills to design persuasive games.

Based on the next part of step 2, final adjustments will be made and the game developed with this considerate user-centered design will be subsequently used in the first real experiment of the research project. In the first experiment, a "media comparison" study [13], families will play the (redesigned) game or use the energy dashboard version in the control condition. Possible new generated suggestions for redesigning from this study will be addressed in a next future paper. We assume our method in taking all design steps will result in a final game design that is effective in changing behavior, knowledge and attitude and engage players during playing.

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