Exploring the use of a game to stimulate energy saving in households

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Abstract: This paper presents a study called the Energy Battle, a game aimed at encouraging home occupants to save energy. Twenty student-households were provided with direct feedback and an online platform with energy feedback over time, ranking of the competing teams, tips and a game. The study showed that the game context strongly influenced the motivation to save energy. Overall, savings averaged 24%, with the highest savings level at 45%. Directly after completion of the Energy Battle, energy consumption increased among most of the households, although consumption levels tended to stay below the baseline measurement level taken before the Energy Battle. Follow-up interviews indicated that some of the behaviours developed in the game had transformed into habits. A game such as the Energy Battle appears to provide a powerful means to stimulate energy saving in the short term. The potential to achieve long term effects appears possible, however further research is required to understand long-term implications for an Energy Battle game.

Keywords: household energy consumption; energy saving behaviour; social incentives; serious gaming.

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1 Introduction

Until recently, the field of eco-design has mainly focused on technological aspects of design. In recent years however, more attention has been paid to user behaviour in relation to product design. While technical innovation can increase efficiency of product operation, user behaviour ultimately has a determining effect on resource consumption. There is an emerging area in design research that is focused on how design can play a role in facilitating sustainable behaviour (e.g., Lilley, 2009; Lockton et al., 2010).

This paper presents a study about a specific case of design for sustainable behaviour, namely the Energy Battle as a serious game aimed at energy saving in households. The game was developed by Shifft, a communication consultancy in cooperation with students of the Faculty of Industrial Design Engineering, Delft University of Technology. The Energy Battle was tested in student households.

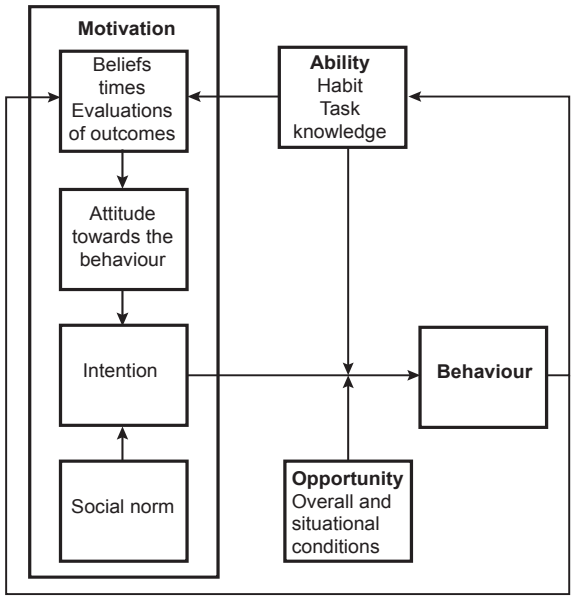
The goal of the study was to explore which role the game and its elements played in facilitating energy saving behaviour. This paper first addresses theory about behaviour and behaviour change, followed by the potential role of games in behaviour change. The case of the Energy Battle as a game to stimulate behaviour change is discussed and the findings of the study are presented.

2 Explaining and stimulating behaviour change

There is a vast body of literature about behaviour and behaviour change in the social sciences. In the field of social psychology, several models have been developed to explain behaviour and behaviour change. Most of these models focus on the individual and internal factors determining behaviour. Consumer behaviour however is largely influenced by external factors, such as social norms and the availability of resources.

In a literature review by Jackson (2005), he points out that there are few models that attempt to include both internal and external factors that determine behaviour. An example of a model that integrates both internal and external factors, is the motivation-opportunity-ability (MOA) model of consumer behaviour, developed by Ölander and Thøgersen (1995). It has successfully been applied in empirical studies (Jackson, 2005). As shown in Figure 1, the model defines three main factors that influence behaviour: motivation, ability and opportunity.

Figure 1 The motivation-ability-opportunity-behaviour model



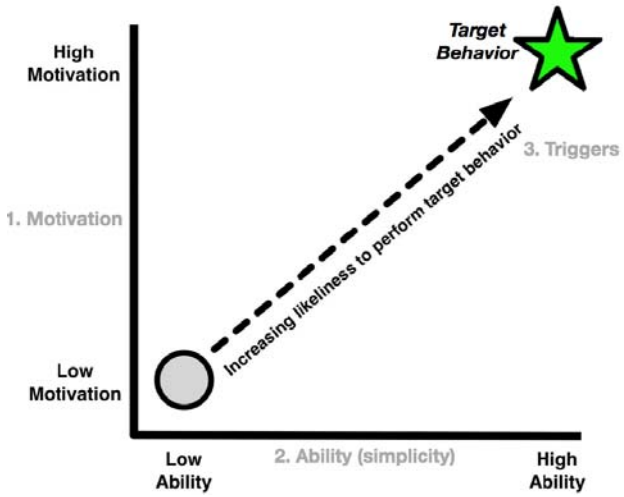
Source: Ölander and Thøgersen (1995)

Motivation is determined by the beliefs about and evaluation of outcomes of a behaviour, which in turn influences the attitudes towards certain behaviour and the intention to actually perform the behaviour. In addition, the intention to perform certain behaviour is influenced by social norms concerning the behaviour. This social norm refers to the subjective norm of the theory of reasoned action, which is a person's perception of how others think one should or should not act (Ajzen and Fishbein, 1980). The factors ability and opportunity facilitate the step from intention to the actual performance of behaviour. Ability to perform the behaviour is based on knowledge about how to perform the behaviour as well by habits which 'shortcut' the intentional process. Opportunities are contextual circumstances (external factors) that make performance of behaviour convenient or can trigger certain behaviour, for instance the placement of waste containers close to someone's home.

A model that is closely related to the MOA model, is the Fogg behaviour model (Fogg, 2009), which is intended to support the design practice in stimulating certain behaviour. This model states that the higher motivation and ability are, the more likely it is that a person performs the target behaviour (Figure 2). Triggers can be used to increase ability and/or motivation. Examples of triggers are the alarm of a kitchen timer or a message that you should return books to the library. According to Fogg, triggers are to be

used first to stimulate certain behaviour. If that is not sufficient, one has to focus on improving ability. Triggers and ability are easier to address than motivation.A trigger in the Fogg behaviour model is comparable to 'opportunity' in the MOA model. Both refer to changes in contextual circumstances.

Figure 2 Fogg behaviour model (see online version for colours)



Source: Fogg (2009)

Most people have a positive attitude towards saving energy. Positive attitudes to the behaviour however do not provide a clear prediction that the behaviour will actually be performed (Ölander and Thøgersen, 1995). Stern (2000) addressed the effect of contextual factors on behaviour. Contextual factors can include a variety of external influences such as incentives, physical capabilities and constraints, interpersonal influences, institutional and legal factors, public policy support. Stern implies that when the context effect is small or neutral, the attitude of the user plays a significant role. Attitude has little influence on behaviour however, when it is strongly influenced by the context. A similar approach is proposed by Zachrisson and Boks (2012) for product design. He argues that for the intended behaviour to occur, the user has to have a positive or neutral attitude towards the behaviour.

This influence of context relates to the opportunity-element in the MOA-model, that facilitates certain target behaviour. Gardner and Stern (1996) describe that incentives can be very effective in changing behaviour. A characteristic of incentives is however, that when they are removed the behaviour is often not maintained.

Habits are part of the ability factor in the MOA-model and the Fogg behaviour model. Habits strongly determine the behaviour of people. Therefore interventions aimed at changing behaviour, will have to address habitual behaviour as well as intentional behaviour. According to Verplanken and Wood (2006, p.100), to successfully change old and establish new habits, interventions must: "(1) change the context cues that trigger existing habits, (2) establish incentives and intentions that encourage new actions, and (3) promote repetition of new actions in stable circumstances".

This is in the same line as the apparent consensus that behavioural change involves the 'unfreezing' of existing behavioural patterns and the elaboration of new alternatives,

as observed by Jackson (2005) referring to Lewin (1951), Spaargaren and Van Vliet (2000) and Biel and Thögersen (2007)

Feedback information about energy consumption has proved to be an effective means to enable people to change their energy consumption behaviour. The information supports the development of task knowledge, the second element of ability.

As the reviews by Abrahamse et al. (2005) and Fischer (2008) show, there have been numerous interventions using feedback to stimulate energy saving. Basic requirements for feedback are that it has to be given frequently, over a long period of time and should enable users to see the consequences of their activities (e.g., the effect of using the washing machine).

It is not enough to simply present the feedback information, it should be presented in such a way that it motivates action (Wood and Newborough, 2007). Or as McCalley and Midden (2002) found: feedback is only effective when it helps to achieve a goal the user has. Thus feedback has to be a tool that enables reaching a goal.

In a similar way, tips will only be effective when they help users to fulfil a goal. While feedback only gives information about the results of (energy saving) activities, tips provide knowledge about how to save energy.

Based on the theory presented above, one may expect the Energy Battle to have a strong effect on energy saving behaviour. The contextual circumstances are changed and, as explained in Section 4, and the ability to perform the behaviour is improved with feedback information and tips. The question is however to what extent behaviour changes would be maintained after completion of the Energy Battle.

3 Games to stimulate energy saving

Games can be considered as a specific type of intervention to stimulate behaviour. Playing a game allows people to step outside of the ordinary (Huizinga, 1949; Caillois, 1962). They have the characteristic to let people do things differently than normal, to stretch the boundaries of the imaginable. When games are designed with the aim of education or training, they are referred to as serious games. The same principles as for normal games apply for the development of these games, with the addition that they have to fulfil learning goals, rather than just entertain.

Games tap into intrinsic motivation. They are inherently engaging. Fogg (2003) argues that intrinsic motivation is powerful in persuading people to perform certain actions. Intrinsic motivation is a type of energising force that arises directly from an activity or situation. Malone and Lepper (1987) defined seven types of intrinsic motivation as: fantasy, curiosity, control, challenge, competition, cooperation and recognition.

Considering that changes in contextual circumstances may stimulate behaviour change, as discussed in the previous section, games could offer a means to change circumstances in an engaging way. By stepping out of the ordinary situation into a game context, they have the potential to let persons ‘unfreeze’ their existing behavioural patterns and ‘refreeze’ different behaviours while or after playing.

There has been limited research so far about games as a form of intervention for saving electricity. Four studies are discussed here.

Petersen et al. (2007) describe a student dormitory competition. They introduced feedback, educational information and an incentive. In the two weeks during competition,

overall electricity use reduced by 32%, whereby dormitories that received weekly feedback based on meter reading reduced 31% and dormitories that received web-based real-time feedback reduced 55%. The authors do not report on energy consumption trends following the competition.

The incentive to participate was provided in the form of an ice cream party for the winning dormitories. Hardly anyone attended this party. This suggests that the motivation to participate was based on the competition, rather than the final prize.

Odom et al. (2008) organised an energy and water saving competition in ten student dormitories with the aim to test the visualisation of web-based information. The result of the competition was "an estimated combined avoidance of 33,008 kilowatt hours (kWh) of electricity and 724,322 gallons of water compared to baseline consumption of the previous three years" [Odom et al., (2008), p.1]. They found social motivation to be a key component for success of the competition. They suggested that to motivate energy saving behaviour, social motivation should take first priority along with the provision of concrete suggestions on how to save energy.

Whereas the two dormitory competitions were relatively simple in terms of game design, the following games apply mechanisms that are used for computer games, for instance by letting the players take on special roles. Power Agent is a mobile game in which the players are special agents fulfilling missions for energy related behaviour (Gustafsson et al., 2009). Teenagers from different families form a team and compete with teams on other locations. The players have to fulfil missions once a week that are unlocked via a game on their cell phone. This game also allowed them to gain tips for energy saving related to the mission. The missions are function related, e.g., to cooking or heating. Up to 50% per mission was saved. Family members participated indirectly, and in varying degrees of enthusiasm. The teams reported to undertake activities that infringed their comfort. In one of the families, even a structural change was made to the house by modifying the heating installation. The social interaction in the form of peer pressure from the team members and the cooperation of family members were reported to be very motivating. Long-term effect on energy consumption was not measured.

Power Exchange (Bång et al., 2009) was also a mobile phone game for teenagers. The design was based on the findings of the Power Agent trial. The hypothesis was that more casual game play and real time feedback based on a real time sensor system could stimulate longer lasting effects. The players were represented as avatars. There were four modes of interaction. Two of them focused on saving energy, which was represented in the state of the habitat of the avatar and a position in a ranking (a pile) of avatars. The two other modes concerned learning about appliances, which took place through duels with other players. The players were not guided in their energy saving as in the Power Agent game, though they could gain insight by playing duels. The game was played for one week. Ten weeks after, the energy consumption continued to be monitored. On average, the consumption in this period was 14% lower in the player group than in the control group. The researchers concluded that the Power Explorer trial showed indications for a long term effect on energy consumption, a significantly positive attitude change towards energy savings, the forming of energy saving strategies in the form of new habits and less extreme energy saving energy measures compared to the trial with Power Agent.

Although the studies described here were exploratory in nature, some lessons can be learned. The dormitory studies show that competition between households based on feedback, real-time as well as weekly feedback, can be effective in stimulating

high-energy savings. The findings suggest that prizes may not be the main reasons for participation, but that the contextual situation, including the competition between and cooperation within households are likely key motivating aspects of playing the game.

Games can provoke extreme behaviours that infringe on comfort. The Power Explorer study suggested that a casual game may not have very extreme energy saving behaviours, but that changes in behaviour are maintained and habits changed. Apart from the Power Explorer study, none of the studies reported on long-term effects on energy consumption behaviour.

These few studies of games aimed at changing energy consumption behaviour show that games have the potential to stimulate behaviour change. There still is however little empirical evidence about how games can be used as an engaging means to stimulate changes in energy consumption behaviour.

4 Energy Battle

The Energy Battle is a serious game developed by Shifft, a spin-off company of Delft University of Technology. An initial version of the game was tested with student households and focused only on electricity consumption. The choice for this target group was of pragmatic nature. A student housing association was willing to provide the necessary access to the energy meters of the student houses. Furthermore, students tend to be eager to participate in gaming events. The current study was seen as a means to provide input towards a next version of Energy Battle aimed at families with children, while also including electricity, gas and water consumption.

The Energy Battle targeted energy consumption in several ways, namely:

a by providing general information about energy consumption of household devices

b making energy consumption visible via feedback

c rewarding energy savings during the game (Versluis, 2008).

The participating houses were provided with an energy meter and access to an online platform. The energy meter, a Wattson (DIY Kyoto, 2010) provided direct feedback on power consumption (Figure 3). Furthermore, it stored data on the consumption over time, which after uploading was displayed via the dashboard (see Figure 4). The players were instructed to upload the data themselves.

The online platform consisted of:

- a ‘dashboard’ displaying electricity consumption over time; per day and per hour (Figure 4)
- tips about electricity saving
- ranking of all the teams
- a game with building blocks (Figure 5).

By saving energy the teams gained credits that could be used to buy building blocks. The more a team would save, the bigger and nicer a construction they were able to build.

Figure 3 Energy meter Wattson (see online version for colours)

Source: Image by DIY Kyoto

Figure 4 Dashboard, electricity consumption over time (see online version for colours)

Source: Image by Shifft

Figure 5 Online game (see online version for colours)

Source: Image by Shifft

The main goal of the game was to save as much energy as possible. A secondary goal was to build a nice construction with the building blocks. The prize for the team that saved most energy compared to the baseline measurement was €750, in kitchen appliances. The team with the most creative construction in the online game would win €250 worth of dining vouchers. This creativity prize aimed to stimulate playing the building blocks game on the online platform.

The Energy Battle was executed in three phases:

1 Baseline measurement of two weeks. Two weeks before the start of the competition the energy meters were installed in the houses to start measuring energy consumption. The inhabitants could not use the meter yet.

2 Competition during four weeks. At the start the participants received information about how to use the energy meter and how to log on to the website. During the competition the households received e-mails to further stimulate participation. After four weeks the two winners were announced.

3 Follow-up measurement. In the month after the competition, the energy meter remained in the household for follow-up measurement to monitor the levels of energy consumption after the competition.

5 Research approach

The main research questions which were considered for the Energy Battle were:

1 What are the motivating factors for participating in the Energy Battle?

2 How much saving would be achieved during the Energy Battle?

3 What activities for saving behaviour would be developed by the teams?

4 What role would the specific game elements serve in the motivating and in enabling increased energy saving behaviour?

5 If people change their behaviour, would it be sustained following the completion of the game?

The game elements in question 4 refer to the elements: direct feedback, feedback over time, tips, prizes, ranking, game with building blocks and teamwork.

Since the researchers were only involved after completion of the game, the research started with an analysis of the data that was collected by the organisers of the Energy Battle: the electricity consumption data and the answers to an online questionnaire held by the organisers directly after the pilot. Since this questionnaire did not provide a lot of insight about motivation and ability, nor long-term effects, complementary semi-structured interviews were held. These interviews addressed the role of the elements of the Energy Battle and the motivation and ability of the participants as individuals and as a team. The interviews were held eight months after the Energy Battle, thus also providing insight in the long-term effect of the Energy Battle.

6 Results

Twenty households (teams) in the City of Rotterdam, The Netherlands participated in the game. The households consisted of two to five persons and were located in three different buildings of a housing association. They were asked to sign up via posters in their buildings, followed up by personal communication by Shifft, the organisers of the Energy Battle.

Of the 20 households that initially started in the competition, 17 households uploaded the measurement data to be included in the ranking of the competition. The households that did not upload data were not able to upload it or had lost interest in participating.

The questionnaire had been sent to individuals in the teams, of which 17 were filled in and returned, representing 16 households (two respondents from the same team).

It was difficult to find respondents for the interviews. Many people had already moved or could not make time for the interview. Four interviews were held with people from teams with both high and low amounts of saving, and of which two of the interviews were with members of the same household (respondent 1, team N, 14th place in the final ranking; respondent 2, team E, 5th place; respondent 3, team G, 7th place; respondent 4, team G, 7th place).

6.1 Main reasons for participation

Both the prizes and the energy savings were important reasons for participation. In the questionnaire, more respondents answered that the awards were more important than the energy saving itself (nine and seven respectively). Due to the small sample size one cannot conclude that the prospect of the prizes was a stronger motivator.

In the complementary interviews another reason was mentioned: curiosity for learning about energy consumption in the home. Respondent 1 stated: "*...we had the idea that it was not very probable that we'd win the competition. But in the end...a reason may have been that we wanted to see if we could achieve some results*".

The team of respondent 2 (team E) was only interested in winning: "*At that time we were still very much into cooking and trying out recipes. You could win kitchen appliances, that stimulated us a lot*". This team was among the households that saved the most electricity.

6.2 Achieved energy savings

The amount of savings in electricity use was 24% overall, with the highest being 45%. Figure 6 shows the amount of saving per household. Seven of the teams reached savings of 30% or more, and only four households did not save more than 10%. Figure 7 shows the amount of electricity consumption per person for each household.

Overall, the reasons for participation do not appear to influence the amount of savings. The teams are equally represented in the higher saving categories (>30%).

6.3 Energy saving activities

The respondents of the questionnaire were asked to list what they had done to save energy. It was an open question. The researcher coded the answers. Table 1 shows a crosstab of the activities and the amount of energy saving.

The most frequently mentioned measure was turning off lights, indicated by 13 of the 15 participants. Turning off lights was followed by less use or different usage of media, less PC or less TV. One respondent mentioned that they substituted watching TV for listening to the radio. Measures involving cooking were mentioned a lot (6 out of 15), mainly related to the electric kettle in terms of boiling less water and direct usage of the hot water. Turning off and unplugging devices to avoid stand-by current was mentioned by 4 out of 15. Turning off the refrigerator (2 out of 15) can be considered a more extreme measure, since it risked spoiling food.

Figure 6 Amount of savings (in %), relative to the baseline measurement (see online version for colours)

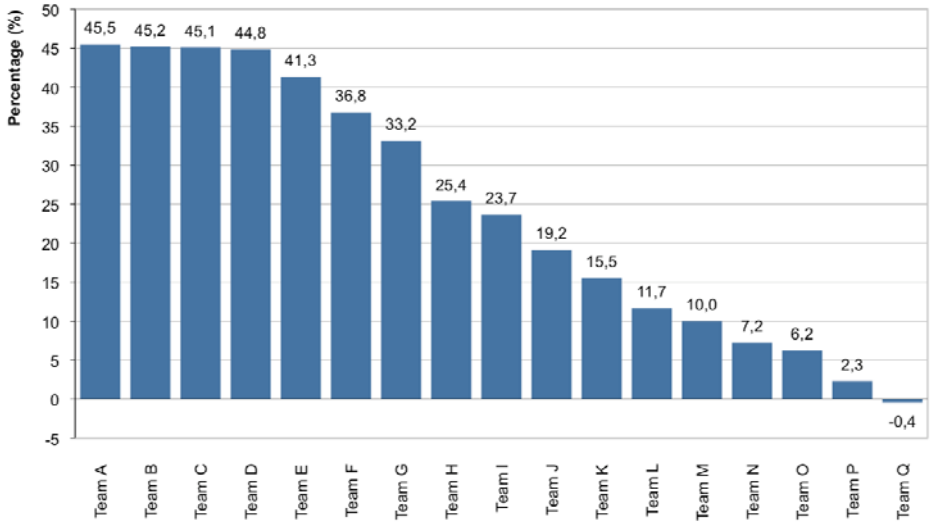


Figure 7 Energy consumption per person per day before (baseline) and during the Energy Battle (see online version for colours)

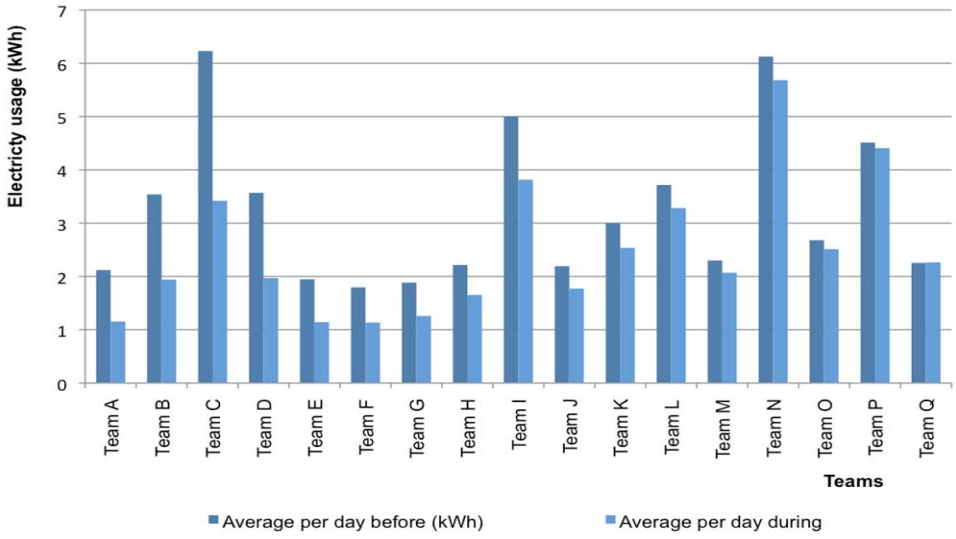


Table 1 Energy saving measures

	*Missing**	*<0%*	*0%–15%*	*15%–30%*	*30%–46%*	*Total*
Lights (turning off/saving bulbs)	1	1	2	3	7	14
Cooking/kettle	1	0	1	0	4	6
Media	1	0	1	3	2	7
Social activities	0	0	0	0	2	2
No standby/unplug	0	0	0	0	4	4
Turn off refrigerator	0	0	1	0	1	2
Personal care	0	0	0	0	1	1
Total respondents	1	1	2	3	8	15

Notes: The percentages stand for the amount of savings achieved, divided in four categories. *Measurement data was not available for this team.

High electricity consuming products such as washing machines and tumble dryers were not reported in the activities.

Remarkable are the social activities that lead to energy saving. Respondents reported to eat together thus cooking in one batch instead of each housemate separately. They also reported that they avoided being at home so they would not use electricity. Furthermore, when looking at the cross-tabulation on the amount of measures taken and the amount of saving it can be seen that, not surprisingly, those who saved most took the most measures.

The responses to the questionnaire provided insight into how much the energy saving activities infringed on their comfort. Most respondents indicated that they had done more to save energy than they found acceptable for comfortable living (8 out of 15, 2 missing). However, 5 out of 15 indicated they could go on like this forever. Of the respondents of households that saved the most, being 30% to 46%, most responded that they did more than desirable to live comfortably (5 out of 8 in this category), while the other three responded that they could have continued comfortable at the achieved level of savings. This could mean that a lot of saving is possible without perceiving a (too big) loss of comfort. And also that the game motivated the teams to do more than is comfortable. To illustrate how the measures influenced daily life: Team E, of respondent 2, explained in the interview how they did far more than what they considered comfortable. They had agreed to have only one computer turned on at a time, meaning that they shared and coordinated computer use. Watching TV was banned. Furthermore, they cooked dinner together, instead of cooking separately, and had dinner by candlelight only.

6.4 Role of elements in savings

There are a number of elements that can be discerned in the Energy Battle: direct feedback, feedback over time, tips, prizes, ranking, game with building blocks and teamwork. The questionnaire addressed some of these elements. The additional interviews the respondents were explicitly asked to give their opinion about the elements of the Energy Battle.

6.4.1 Wattson – direct feedback

The Wattson energy meter was used as a tool to help save energy. The direct feedback was used to find out how much power appliances consumed. The respondents reported that the direct feedback of the meter provided insight and motivated to use less electricity. Furthermore, the respondents stated that the meter drew attention (respondents 1 and 4). In the case of respondent 1, even visiting friends were drawn to the meter and asked for demonstrations.

The game participants indicated via the questionnaire that given the energy meter, the dashboard and the prizes, both the energy meters as well as the prizes were the main motivators to save electricity (7 and 6 respondents of 15 valid responses).

6.4.2 Dashboard – feedback over time

The questionnaire results do not provide a clear answer to whether the feedback over time on the 'dashboard' was useful. In the interviews the respondents on the one hand said it has been very useful: "*very good because it showed us that we should use less*" (respondent 2). On the other hand, there were teams that had problems with uploading the information and as a result could not use the information (respondent 3).

6.4.3 Tips

While six respondents indicated that the tips helped to save energy, also six (of 15) did not have an opinion. This means that they did not see the tips or did not use them, as two of the interviews point out (respondents 2 and 4), or they did not find them helpful. The responses to the questionnaire suggest that the tips contributed to higher energy savings, because respondents stating that the tips were useful for saving energy were from households that saved more than 30%.

In the interviews, we found that the tips helped to discover how to save energy. Respondent 1 for example said that a question about the vacuum cleaner made him try it and look at the energy consumption on the energy meter. As a consequence he now uses the vacuum cleaner less and a crumb sweeper instead.

6.4.4 Prizes

While for those that participated to win the prize it was the main reason to keep on going, others were mainly interested in gaining more insight in energy consumption and saving energy. The questionnaire results suggest that this is about half-half; when choosing between the energy meter, the dashboard and the prizes, both energy meter as well as prizes came out most attractive (7 and 6 respondents out of 15 valid responses).

6.4.5 Ranking

The ranking was important when winning was still possible. According to Versluis (2009) and the responses to the questionnaire, teams who were not able to win anymore because of their place in the ranking lost motivation to save energy. There were also households that did not pay a lot of attention to the ranking since they were only interested how their own household could save energy.

6.4.6 Game with building blocks

The questionnaire results indicate that the building blocks game was challenging and motivating to save energy. The interviews cannot confirm the findings of the questionnaire:

The building blocks game was "*not really important. We wanted the other prize, but we won on this element*" (respondent 2). Her team won the originality prize for nicest construction.

Respondent 1 states: "*...especially in the beginning, we had very little points so we could not really build something. So it was not a motivator*".

6.4.7 Teamwork

The questionnaire did not address teamwork as a factor that influences the energy saving activities in the Energy Battle. Versluis (Personal communication, 2009) indicated that teams that saved a lot of energy were coordinating their activities. The team of respondent 2, which finished second in the ranking, had agreed to eat together and not to use more than one computer at a time. Housemates thus had to coordinate computer use. "We stimulated each other to turn off the lights and used each others computer". Furthermore she said "It was quite funny and cosy, because for a few nights we had been sitting together with candles. It made our house quite cosy".

Teamwork could also include agreements about not being at home. According to respondent 2, and to her annoyance, the members of the winning team were hardly at home.

In other teams agreements were not made explicitly. The team would simply start and discuss their individual findings with each other (respondent 1 and 3). Discussion with the other team members was considered useful: "The best [about the Energy Battle] was that we were now consciously talking about it. Although we did not work on it together so much". [due to different working hours] (respondent 3).

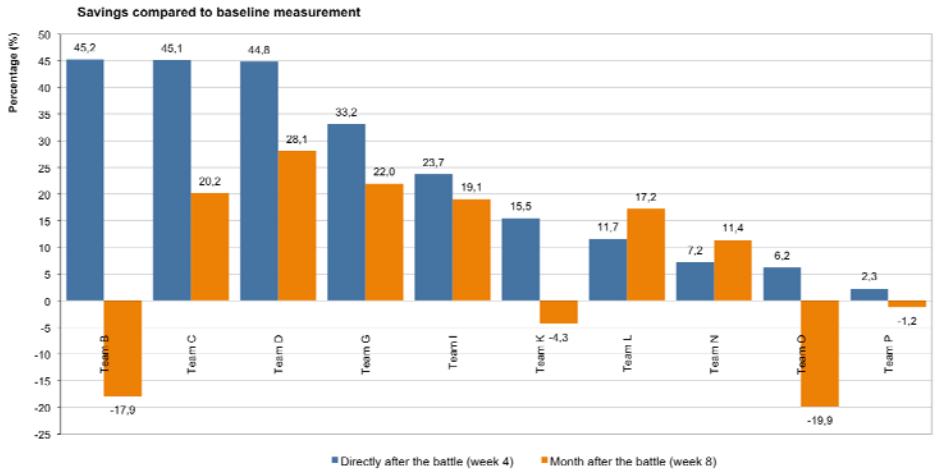
Respondent 1: "We did not really work on strategies ... It just started, that was also my idea, just see how it goes and whether it is of any use to us. In the end it simply is fun to see how the energy consumption regulates itself." Respondent 1 and one of his housemates, wanted to involve a less energy conscious household member to be more conscious about energy use.

6.5 Energy consumption after the Energy Battle

Directly after the Energy Battle, the energy meter remained in the households for a month. Figure 8 shows the relative energy savings after one month. Unfortunately, these data could not be retrieved for all the teams.

Two teams continued to lower their electricity consumption (team L and N). In four of the ten monitored households electricity consumption rose, but still remained below the level of before Energy Battle. Two households (team K and P) have a difference in electricity consumption level before and after the game of less than 5%. This can be considered as returning to the baseline level. Finally, two teams (B and O) use more electricity than before the Energy Battle.

Figure 8 Energy saving directly after and one month after the Energy Battle compared to baseline measurement (in %) (see online version for colours)



Overall, the expectation whether the electricity consumption level would stay below the baseline level was moderate. The responses were six times 'I don't think so', seven times 'maybe a little', twice 'for sure' (15 valid responses) which is comparable to the results above.

6.6 Eight months later...

The additional interviews held eight months after the Energy Battle ended, provide insights into the effects of the Energy Battle over a longer term.

The energy meter was still in the households of respondent 1 and 2. In the house of respondent 2, they had disconnected the energy meter when the official measurements were over. In the house of respondent 1, the energy meter was still working. He mentioned that he looks at it, but that he had not retrieved the data stored on it for historical feedback.

In terms of energy behaviour the interviews indicate that some things have changed, due to the Energy Battle. Respondents say to be more conscious about switching off lights (respondent 2), boiling less water in the kettle and use the water right away instead of reheating it later (respondents 1 and 4).

The team that actively saved energy via extreme measures (respondent 2 of team E) indicated that they maybe were more conscious about their electricity consumption behaviour and that some habits had been developed: "*I am sure that after the Energy Battle we unconsciously took it [energy saving] into account. You did not really think about it, but did turn off the lights or so...Now I always turn off my computer...yeah, I don't know...I am not doing it consciously... and considering what I answered to your questions... we did not really consider saving energy anymore.*"

Those that did not take it to the extreme (respondents 1, 3 and 4) indicated that they continued with all the behaviours they had changed during the Energy Battle.

> "*I try to continue as much as possible with what we started then*" (respondent 1).

> "*During the Energy Battle we did hardly anything different than now*" (respondent 4).

None of the interviewed could tell how much their electricity consumption was at that time. They only guessed that consumption would be lower than or equal to the level before the Energy Battle, based on the changes in their behaviour.

In terms of insight in electricity consumption, they indicated that it either had stayed the same or improved. For as much as discussing the topic of energy consumption amongst the team members, they did not do that anymore after the competition had ended.

7 Conclusions

This study is based on a small sample size in a particular target group. Therefore it is not possible to draw generally conclusions concerning the impact of the Energy Battle on energy consumption behaviour. The study did nevertheless provide insight in the role the game and its elements play in motivation and ability to perform energy saving behaviour.

7.1 Motivations to participate

To answer the first research question: The reasons to participate in the Energy Battle were dominated by either the prizes or the insight in energy saving. This difference in motivation did not appear to influence the amount of resulting energy saving of the teams. This suggests that even when people participate for other reasons than energy saving, a behaviour change can be maintained in the longer term.

7.2 During the game

The amount of energy saving (research question 2) was 23% on average, with more than half of the teams saving more than 30%.

The activities undertaken to reach these savings are mainly related to lighting, media use and cooking. Only one respondent mentioned vacuum cleaning (after a cue from the Energy Battle). No one mentioned measures related to washing machine, tumble dryer or dish washer; appliances that have quite an impact on the electricity consumption of a household. At least a washing machine must have been present in the households. This result suggests that the game design should include guidance to explore all energy saving options.

Concerning the role of the game elements, the feedback from the Wattson and the prizes resulted to be most motivating elements for energy saving during the game. This coincides with the two most mentioned reasons for participation: learning about energy saving and winning the prizes.

The feedback via Wattson and Dashboard, increased the task knowledge of the participants, as was expected from the literature research. In the first month after the Energy Battle the teams were still able to read consumption data of the energy meter. The interviews indicate that the feedback was hardly used after completion of the Energy Battle. Apparently, the game context of the Energy Battle was more influential for energy saving behaviour than the ability to do so. This coincides with the findings of McCalley

and Midden (2002) that feedback only works when it helps the users to achieve a goal. When feedback remains in place after interventions such as the Energy Battle, it may be useful to consider how the intervention can foresee in follow-up goals or stimulate the users to set goals.

The extent to which the tips contributed to task knowledge could not be verified. In future game design, attention should be given as to how tips may contribute to behaviour change in a game context and what effect different types of tips have. The tips can for example be used to better guide the energy saving activities.

The ranking and thereby the chance of winning a prize affected the motivation to save energy during the Energy Battle. Motivation to save energy was high when teams expected to have a good chance to win the game. The motivation dropped however when there was no chance of winning anymore. Further research into the design of a game, should consider how the participants can be motivated throughout the game. Apart from a reward at the end for the winner only, other ways of rewarding should be investigated.

It is not clear what role the building blocks game played in stimulating behaviour change due to the mixed results from the questionnaire and the interviews. While energy saving enabled the game play, energy saving could be achieved without playing the game. This online game thus has to be really engaging for participants to play it or playing the game should contribute to the energy saving goals of the players. Further research has to look at how to better integrate such a game in the overall game dynamics of the Energy Battle.

Cooperation between team members and the competition with other teams influenced the motivation to play the game and thus save energy. The Energy Battle used these intrinsic motivators in a very basic, though successful, manner. Further research could look into different ways to employ intrinsic motivators for energy related behaviour.

7.3 Energy consumption behaviour in the long term

The study yielded mixed results on the energy consumption trends after the game. Six out of ten households stayed below baseline level, while others returned to baseline level or even consumed more.

In general, it appears that the lower levels of energy consumption were not maintained in the month after the pilot, because the competition and social influence among household members were removed and the teams ceased to perform activities that were not considered comfortable. For example, sharing one computer at the time is hard to keep up, when most household members have their own and use it frequently.

During the Energy Battle, the teams took extreme measures that infringed their comfort. We could not find out what the effect was of extreme measures on behaviour change in the long term. Bång et al. (2009) suggest that casual game play with less extreme behaviour has more effect in the long term. Unfortunately, they did not present data comparing long-term behaviour from both extreme vs. casual behaviour changes. Further research should look into the effects of stimulating extreme behaviours versus casual behaviour during a game, both for long-term energy savings as for game play.

Concerning habits, the interviews suggest that new habits were formed, even in a team that was not interested in energy saving. This indicates that a game can be effective in changing habits. The change in context of the energy consuming behaviour appears to have been sufficient to break habitual behaviour and encourage new behaviour. For behaviour that was often performed, such as switching of lighting, unplugging adapters

and putting on the kettle with less water, the repetition may have been sufficient and long enough to transform habits.

Maintaining behaviour over a long period is a critical factor for using games as interventions to change behaviour. Further research is necessary to explore in what ways a game can support long-term behaviour change. Using gaming as part of a broader long-term programme of products and services (with or without game elements) could be a way to provide a context and stimuli that facilitate energy saving behaviour, or sustainable behaviour in a broader sense, in the long term.

The test of the Energy Battle in student households demonstrates the potential for creating insight among households on how to save energy and the formation of new habits. The next step would be to make a translation of the findings from this study to tailor the Energy Battle for other target groups, such as families with children.

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