GAMING FOR ENERGY CONSERVATION IN HOUSEHOLDS

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Abstract

This paper presents a study about a 'serious game', "Energy Battle", as a means to influence energy-related behavior in households. The Energy Battle is designed to engage home occupants in a fun way in energy conservation via a competition with other households. The challenge enabled home occupants to gain insight in their energy consumption and actively involved them in reducing energy consumption. The energy reduction was registered online and information and tips on the online platform were given to help the participants to reduce energy consumption. The game is tested in 20 student-households in the city of Rotterdam. The evaluation of the pilot focused on behavioral changes in the short and in the long term and on the role of social interaction in the game. The Energy Battle in the Rotterdam households resulted in an average reduction of 24% in electricity consumption. Eight months later the participants indicated that only a few of the behaviors developed in the game were maintained. In interviews and questionnaires the participants indicated that the game made them more aware of energy consumption in their household and how to influence it. Additionally it affected social aspects, such as dining together to save energy and the ability to discuss a topic that otherwise was avoided. Based on the results of the first study a second study is being set up with families to gain deeper insight in the effect of the social interaction in the game on behavior change in the short and in the long term.

Keywords

Consumer behavior, serious gaming, energy conservation, social interaction

1. Introduction

Until recently the field of eco-design has mainly focused on technology aspects of design. In recent years more attention has been paid to user behavior in relation to product design., Technical innovations may increase efficiency of product operation, but ultimately the user's decisions and habits have a determining effect on resource consumption. Products and services can play a role in changing behavior and habits towards more sustainable behavior. In this paper we will present an evaluation of a serious gaming approach, the Energy Battle, designed as a means to influence energy consumption behavior in households with a potential for radical behavior change.

2. The Energy Battle

Energy Battle is a serious game developed as a means to influence reduced energy usage and as a step toward 'smart energy consumption'. The game was developed by Waanzinnig!, a communication consultancy, and by students and staff at Delft University of Technology, Faculty of Industrial Design Engineering. The goal of the Energy Battle is to stimulate 'smart energy consumption'. 'Smart energy consumption' refers to being aware of the influence one's behavior has on energy consumption levels, including electricity and gas, while taking availability of local renewable energy sources into account.

The target group for the Energy Battle is households with more than two members, with a focus on families with children, whereby children playing the game can lead to involvement by parents. However, student households or other community-based groups are also considered as part of the target group. This target group was chosen, given that interaction between the members of a household could stimulate energy conservation and can lead to innovative ways of energy conservation. Household members can stimulate each other in the game and correct each others' energy wasting behavior.

The game targets energy consumption in several ways:

- It provides general information about energy consumption of household devices in order to change attitudes and ability to perform energy saving behavior.
- It makes energy consumption visible, thus providing the participants a means to monitor their energy consumption and act upon it (i.e., increasing sense of ability).
- It motivates energy saving by rewarding energy saving behavior during and at the end of the game.
- Progress in the game (more saving, gaining points) confirms the ability of the household members to actually change behavior.
- Working as a team in a competition generates a social norm for energy saving behavior.

In 2009 a first pilot took place. The Energy Battle was tested in student households. The goal of the pilot was to test the working of the game and to find out if the game set up would actually lead to significant and long-lasting energy reduction. The study discussed in this paper is based on this pilot.

2.1 Pilot in student households

Twenty households (teams) in the city of Rotterdam in the Netherlands joined the Energy Battle. The households were located in three different buildings of a student housing association. The households consisted of 2 to 5 persons per household. For practical reasons the Energy Battle focused on electricity consumption only.

The teams were asked to sign up via posters in their buildings, followed up by personal communication by the organisers of the Energy Battle. Two prizes would be awarded; a prize for the team that saved most energy, € 750,- in kitchen appliances, and a prize for the most creative construction in the online game.

The pilot consisted of three phases:

1. A baseline measurement of two weeks. Two weeks before the start of the competition Wattson energy meters (DIY KYOTO, 2010), see figure 1 were installed in the houses to start measuring energy consumption. The inhabitants could not use the meter yet.

Figure 1: Energy meter Wattson. Image by DIY Kyoto.

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.

Each house had an energy meter for real time energy feedback and access to an online platform. This platform consisted of a 'dashboard' displaying electricity consumption over time, per day and per hour (figure 2), tips about electricity saving, ranking of all the teams and a game with building blocks (figure 3).

The teams gained credit by saving energy. These credits could then be used to buy building blocks. The more a team would save, the bigger and nicer a construction they could build.

The teams had to upload the data themselves and could decide when and how often to do it. Only after uploading the data from the energy meter could they see the data in the dashboard.

After four weeks the winners were announced. They were determined by the relative amount of saving compared to the baseline measurement and for the creativity prize by the looks of the construction.

3. Follow-up measurement. In the month after the competition the energy meter stayed in the household for follow-up measurement to see what happened to the levels of energy consumption after the competition.

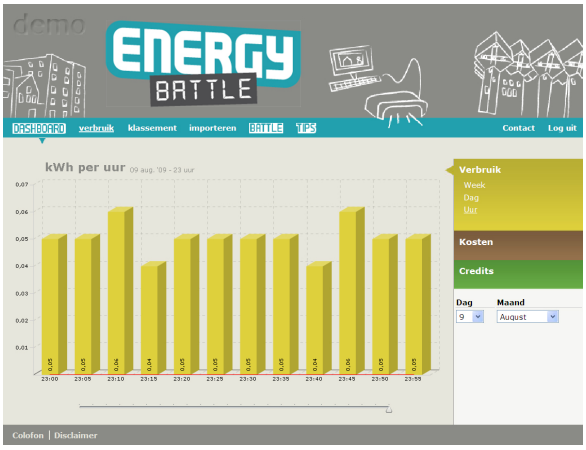

Figure 2: Dashboard, electricity consumption over time (image by Waanzinnig!)

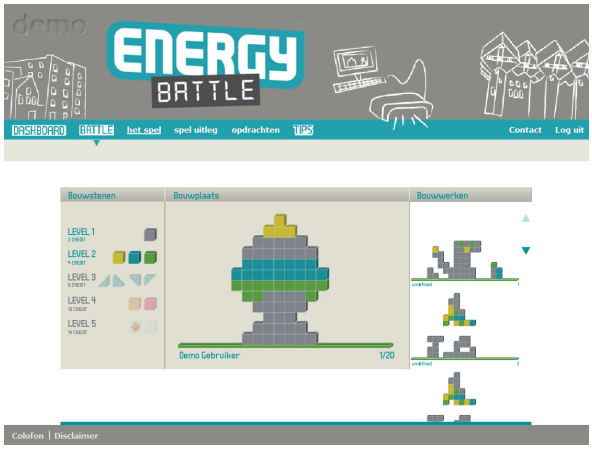

Figure 3: Online game (image by Waanzinnig!)

3. Related work

There has been little research so far about games as interventions for saving electricity using interactive technology. Three studies were found:

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 real-time feedback remained available two weeks after the competition and was still consulted, though less than in the period of the competition. Students reported that they would continue their energy saving activities after the competition. The authors do however not report about energy consumption after the competition.
The education consisted of materials posted in all dormitories describing the environmental impacts of electricity and water consumption. The incentive to participate was provided in the form of an ice cream party for the winning dormitories. The authors suggest that the students were generally not motivated to participate because of the incentive, because of the low attendance to the ice-cream party.

Odom et al. (2008) also organized a energy saving competition with 10 student dormitories with the aim to test the visualization of the web-based information. The saving over the one month period was 33008 kWh. How much reduction that is in relation to the baseline is not mentioned. They found social motivation as a key component for success of the competition since the students appeared to be largely unmotivated to change their behavior on their own. Furthermore they found that concrete suggestions for saving behaviors were important.

Power Agent (Gustafsson et al., 2009) is a mobile game in which the players are special agents fulfilling missions for energy related behavior. Teenagers from different families form a team and compete with teams on other locations. The players have to fulfill missions once a week that are unlocked via a game on their cell phone. This game additionally 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% was saved per mission. Family members participated indirectly, and in varying degrees of enthusiasm. The teams reported to undertake activities that infringed their comfort. 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 has not been measured, though some families made adjustments in their home which, without further effort of the inhabitants would have a long term effect on energy consumption.

All three studies are very specific and cannot easily be generalized. This also counts for this study about the Energy Battle. However, this study may add to findings of the studies discussed above with insight on the long-term effect of a competition, real-time electricity

feedback on a specific display rather than a computer screen and insight in the elements of the game.

4. Research approach

After the pilot, there was a need for additional insight in how the energy Battle contributed to 'smart energy behavior'. An evaluative study was conducted after the Energy Battle, guided by the Motivation-Opportunity-Ability model of consumer behavior by Ölander and Thøgersen (1995). This model was chosen because it integrates several theories about consumer behavior and with the factors 'opportunity' and 'ability' makes explicit how an intervention can influence behavior.

The main question of the study is how the Energy Battle influenced motivation, ability and actual energy saving behavior during and after the competition.

4.2 Method

The study was conducted as an evaluation, after the pilot project already had ended. Therefore, the research team 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 directly after the pilot. Since this questionnaire did not provide a lot of insight about motivation and ability, nor long term effects, a few complementary semi-structured interviews were held that went more into depth about the role of the elements of the Energy Battle, 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 effect of the Energy Battle on a long term.

5. Results

Of the 20 households that initially started in the competition, 17 households generated measurement data (by uploading) and could be included in the ranking of the competition. The frequency of uploading varied over the teams.

The questionnaire was sent to individuals in the teams, of which 17 were filled in and returned, representing 16 households (2 respondents from the same team).

It was difficult to find respondents. Many people had already moved or could not make time for the interview. Four interviews were held with both a lot and little saving and of which two of the interviews were with members of the same household. Respondent 1, team N, 14th place, Respondent 2, team E, 5th place, Respondent 3, team G, 7th place, Respondent 4, team G, 7th place).

5.1 Amount of saving

The amount of savings in electricity use was overall 24%, with the highest being 45%. Figure 4 shows the amount of saving per household. Seven of the teams reached savings of 30% or more, and only 4 households did not save more than 10%.

Figure 5 shows the amount of electricity consumption per person for each household. A marginal effect was found for the amount saved in relation to baseline electricity consumption with a regression analysis (ANOVA). 23% of the saving could be accounted for by the baseline electricity consumption with a borderline significance of 0,055 (df = 1, 15; F= 4,343). This indicates a marginal effect, but a larger sample size is needed before definitive conclusions can be drawn.

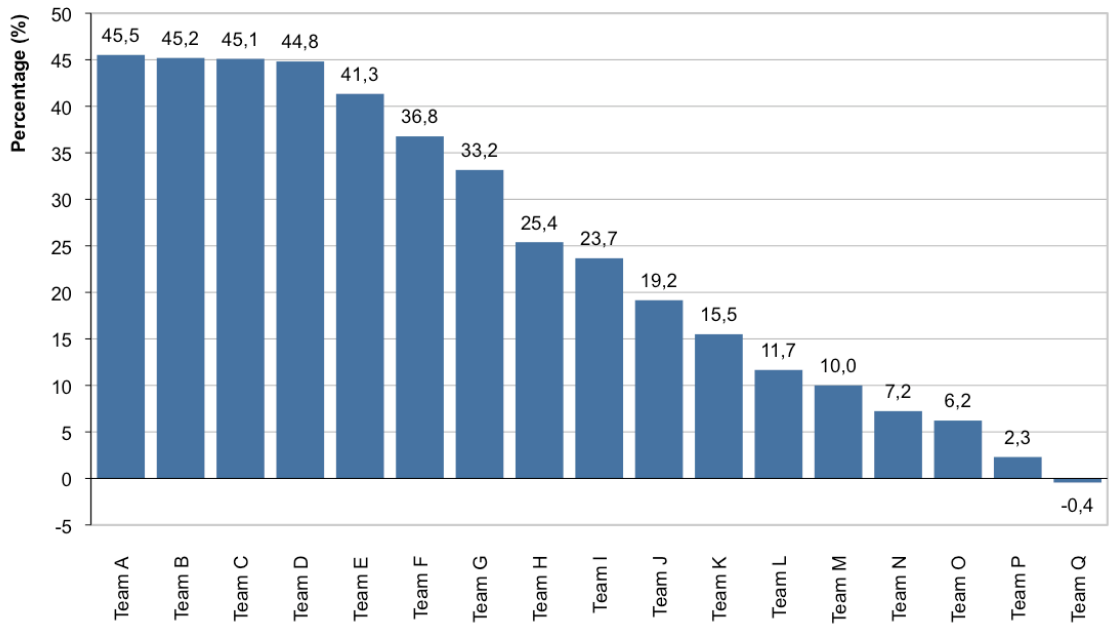

Figure 4: Amount of savings (in %), relative to baseline measurement

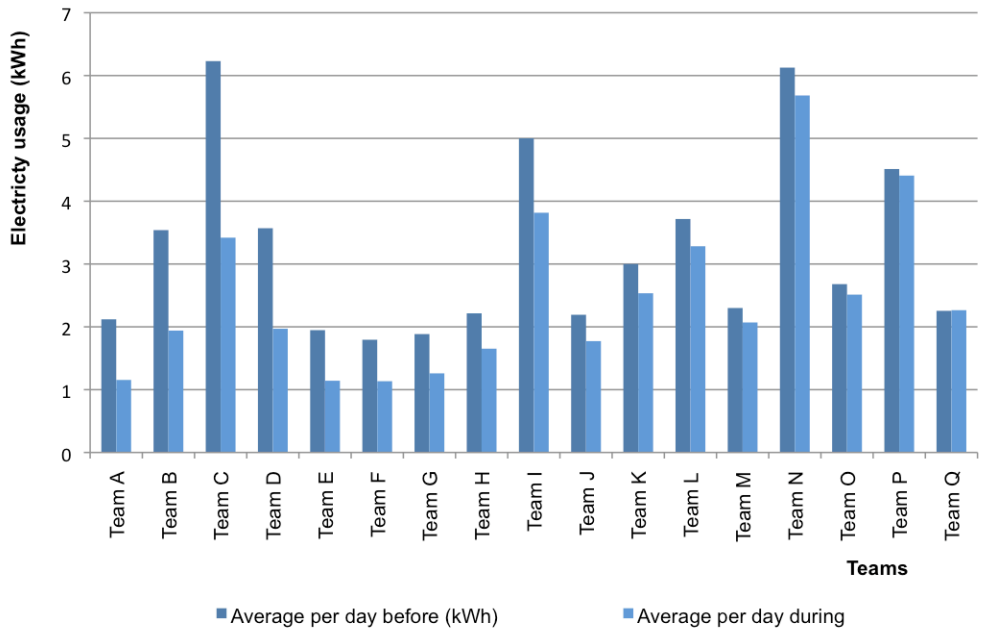

Figure 5: Energy consumption per person per day before (baseline) and during the Energy Battle

5.2 Main reasons for participation

Both the awards and the energy savings were important reasons for participation. In the questionnaire more respondents answered that the awards were important than the energy saving itself (9 and 7 respectively). Due to the small sample size we cannot conclude though, that the prospect of the prizes was a stronger motivator.

In the additional 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 we'd win the competition. But in the end...a reason may have been that we wanted to see if we could have 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. And you could win kitchen appliances, that stimulated us very much.*" This team was actually amongst the most saving households.

5.2 Activities for savings

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

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

The most mentioned measure was turning off lights, by all except for two respondents who did not list any activities. This was followed by less use or different usage of media, less PC or less TV. One respondent mentioned they substituted watching TV for listening to the radio. Also measures involving cooking, mainly related to the electric kettle were popular (6 of 15) and turning off and unplugging devices to avoid stand-by current (4 of 15).

Turning off the refrigerator (2 of 15) can be considered a more extreme measure.

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. And they also reported to not be at home so they would not use electricity.

Furthermore, when looking at (the cross-tabulation of) the amount of measures taken and the amount of saving it can be seen that, not surprisingly, most measures were taken by those who saved most.

High electricity consuming products such as washing machines and tumble dryers, were not reported.

5.3 Impact on lifestyle

Most respondents indicate that they have done more to save energy than they found acceptable for comfortable living (8 of 15, 2 missing). However, 5 of the 15 indicate they could go on like this forever. Of the respondents of households that saved most, between

30-46%, most responded that they did more than desirable to live comfortably (5 of 8 in this category), while the other 3 responded that they could go on like this. 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 lifestyle: Team E, of respondent 2, did far more than what they considered comfortable. They agreed to have only one computer turned on at the time, meaning that they would share and coordinate computer use. Furthermore they cooked dinner together, instead of cooking separately and ate the dinner by candlelight only. Watching TV was banned.

5.4 Role of elements in savings

There are a number of elements that can be discerned in the Energy Battle: energy meter, dashboard, tips, game and ranking. The questionnaire addresses some of these elements. The additional interviews the respondents were explicitly asked to give their opinion about the elements of the Energy Battle.

5.4.1 Wattson – direct feedback

The Wattson was used as a tool to save energy. The direct feedback was used to find out how much power devices 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 draws attention (respondent 1 and 4). In the case of respondent 1, even visiting friends were drawn to the meter and asking for demonstrations.

When asked in the questionnaire to choose between the energy meter, the dashboard and the prizes, both the energy meters as well as the prizes came out most as motivators to save electricity (7 and 6 resp. of 15 valid responses).

5.4.2 Dashboard – feedback over time

The questionnaire does not provide a clear answer to whether the feedback over time on 'the dashboard' has been useful. The interviews show what may have caused these differences. On the one hand the respondents say 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). Also could interpretation of the data have been a problem, as this comment by respondent 1 illustrates: *"it produced funny, though logic results... if I remember well between five and six in the morning we used the same as somewhere*

around the same time in the afternoon. But then if was lowest at that time, why was it not the same between two and three in the night?". He could not explain the variations in the consumption pattern.

5.4.3 Prizes

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

5.4.4 Ranking

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

5.4.5 Game with building blocks

The questionnaire results indicate that the game was challenging and motivating to save energy. The interviews cannot confirm the findings of the questionnaire:
The battle was *"not really important. We wanted the other price, though we won with this element"* (respondent 2). Her team won the originality prize for nicest construction.
"...especially in the beginning, we had very little points so we could not really build something. So it was not a motivator" (respondent 1).
"Funny addition, but since the uploading of data did not go well, this did not go so well either" (respondent 3).

5.4.6 Tips

While 6 respondents indicate that the tips helped to save energy, also 6 (of 15) did not have an opinion. This means that they either did not see or use the tips, as two of the interviews point out (respondent 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 the 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 as a consequence now uses the vacuum cleaner less and a crumb sweeper instead.

5.4.7 Teamwork

The questionnaire does not address teamwork as a factor influencing the game. Personal communication with Versluis (2009) indicated that teams that saved a lot of energy were also coordinating their activities. The team of respondent 2, which finished second, 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 of the lights and used each others computer"*. Furthermore she said *"It was quite funny and cosy, because for a few nights we had only been sitting her together with candles. It made it quite cosy in the house"*.

Teamwork could also include agreements about not being at home. According to respondent 2, the winning team did not work as close together as her team and to her annoyance they were hardly at home.

For other teams agreements were not explicitly made. 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 battle] *was that we were now consciously talking about it together. 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 if 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.

5.5 Energy consumption after the Energy Battle

Directly after the Energy Battle, the energy meter remained in the households for a month. Figure 6 shows the relative energy savings after one month. The changes in energy consumption per household per person are shown in figure 7. Unfortunately, these data could not be retrieved for all the teams.

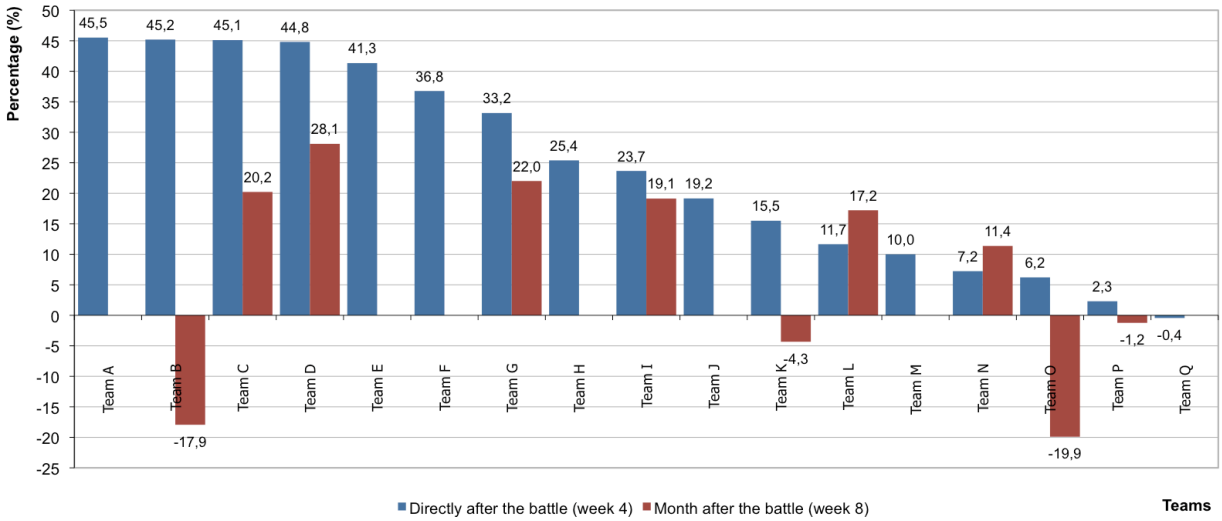

Figure 6: Energy saving directly after and one month after the Energy Battle (in %).

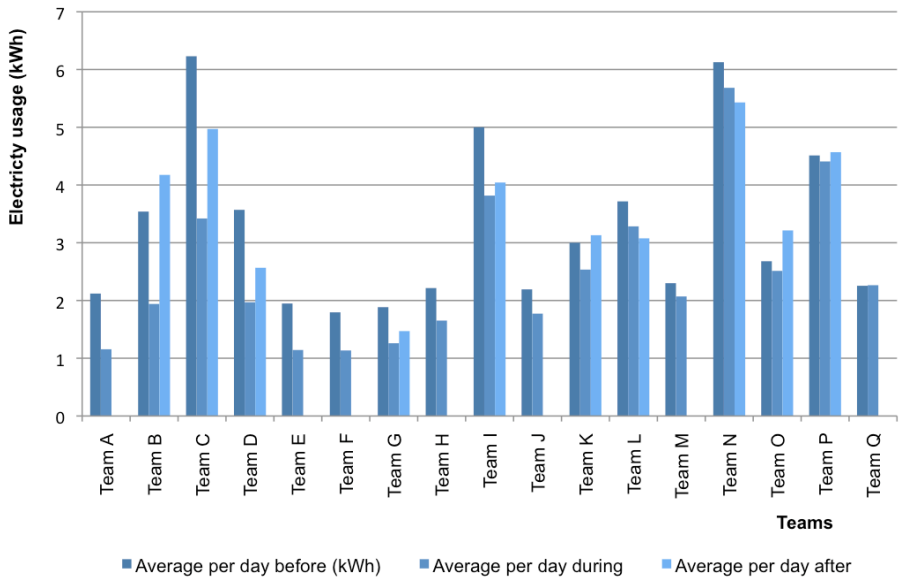

Figure 7: Energy consumption per household per person, before (baseline), during the Energy Battle and in the first month after the Energy Battle.

Two teams continued to lower their electricity consumption (team L and N). In 4 out of the 10 households measured, 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.

Overall the expectation if the electricity consumption level would stay below the baseline level was moderate. The responses were 6 x 'I don't think so', 7 x 'maybe a little', 2 x 'for sure' (15 valid responses). Which is comparable to the results above.

5.6 Eight months later...

The additional interviews were held eight months after the Energy Battle had ended and thus provided insight in the effects of the Energy Battle on 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 to look at it, but never to have retrieved the data stored on it.

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 (respondent 1, 4).

The team that very actively saved (respondent 2 of team E), taking extreme measures, indicated that they may be more conscious using electricity and have formed some habits: *"Well, I'm not sure since we...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 of the lights or so...Now I also 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. So it seems that also a change in habits was achieved.

"Yes, in principle we still do it. At least...I do not have the measurements of course but I try to continue as much as possible with what we started then" (respondent 1).

"During the 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 it could be lower than or equal to before the Energy Battle based on the changes in their behaviour.

In terms of insight in electricity consumption, they indicated that it either stayed the same or improved. And for as much as discussing the topic of energy consumption, they did not do that anymore once the competition had ended.

6. Discussion

The results of the Energy Battle pilot study are based on small samples. Therefore we cannot draw definitive conclusions about the impact of the Energy Battle on energy consumption behavior. The study was however sufficient to provide insight in the potential the Energy Battle has to influence energy consumption behavior.

The motivations to participate in the Energy Battle are dominated by either the prizes or the insight in energy saving. From the interviews we see that for both cases the Energy Battle resulted in a change in habits with the participants or even a whole team.
What can be learned from this is that when you manage to engage people to participate in a serious game, based on the rewards, the 'side effects' for the participants can be a change in behavior. Those participants may also be more radical in their changes during the game, which, if the game facilitates it, may even lead to new practices that are still considered comfortable. A study about bathing practices showed how practices could change due to people experimenting with alternative ways of doing. (Kuijer and de Jong, 2009).
What should be considered is that the people that participated because of the rewards may already be inclined, or at least not opposed to, the behavior change the game aims for.
Other studies about competitions for energy saving do not mention the reasons why people participated, or how they became involved in the game, (see e.g. Petersen et al. (2007) and Gustafsson (2009). More insight in how to engage people in this kind of games is necessary to be able to reach a large amount of people with a broad range of motivations and abilities.

The activities undertaken in the Energy Battle are mainly related to lighting, media use and cooking. It is remarkable that cleaning is not mentioned in the energy saving activities. Only one respondent mentioned vacuum cleaning (after a cue from the Energy Battle) and no one mentioned measures related to washing machine, tumble dryer or dish washer. In general however, these have quite an impact on the electricity consumption of a household. At least a washing machine must have been present in the households. A question that rises from this observation is how the Energy Battle can (and should) guide the participants more in the kind of activities to focus on in order to reach significant energy savings in the household.
The Power Agent game (Gustafsson et al., 2009) guided the participants through various clues that could be obtained via a computer game. Additionally did each mission of the Power Agents (the players) focus on a different function, for example kitchen electricity use. This way the game makes sure that all relevant saving options are addressed.

During the Energy Battle the teams were motivated to take extreme measures that infringed their comfort. We could not find out what the effect was of extreme measures on behavior change on the long term. It would be worth finding out if it has stronger effects, and as a consequence facilitate extreme behavior in all teams during the whole or part of the game.
In the Power Agent game (Gustafsson et al., 2009) participants also compromised comfort to fulfill a mission, up to making permanent changes in their home. The latter kind of change does not require a long lasting behavior change, but is nevertheless very valuable in reducing energy consumption. Once installed such changes do not require continuous effort, while maintaining behavior in general does. Stimulating adjustments to the house or influencing purchase decisions can be a made part of the Energy Battle.

During the Energy Battle, like in the other studies about competitions (Odom et al., 2008, Petersen et al., 2007, Gustafsson et al., 2009) the energy savings are higher than reported in other studies about interventions aimed at energy saving, as described by Abrahamse et al. (2005), which report maximum savings around 20%. This can be explained by the higher motivation due to the game context. There are no indications however, that savings will be higher in the long term compared to interventions that are not competitions.

If we refer back to the Motivation-Opportunity-Ability model of consumer behaviour (Ölander and Thøgersen, 1995) what can be said about the effects of the Energy Battle? Motivation to save energy during the Energy Battle was high. Either did teams expect to have a good chance to win the game or, if they did not expect to win, they expected to be able to save energy and maybe even change future behavior in their household. Peer pressure (social norms) of the team members and the fact to be competing with other teams, influenced the intention to play the game and thus save energy.

The ability to save energy came from basic knowledge (Respondent 1: *"Anyone knows about turning of lights etcetera"*). Furthermore the energy metering during the Energy Battle provided tools to gain insight in the amount of consumption and the effect of activities, and the tips contributed to improve the insight.

The Energy Battle can also be considered as a condition that facilitated energy saving, an opportunity. It was an incentive to undertake activities for energy saving. It made saving energy a topic of discussion, thus energy consumption and saving possibilities a conscious behavioral process.

Overall the levels of energy consumption rose after the Energy Battle indicating that the energy saving behaviors were not maintained, or at least not as strict, as during the Energy

Battle. The questionnaire and the interview results suggest that attitudes towards energy saving have not changed, not for those with a positive, nor those with a neutral attitude.

The households had gained task knowledge. And as the interviews show, habit formation took place, even in a team that was not interested in energy saving.

In the first month after the Energy Battle the teams were still able to read consumption data of the energy meter. So they should still be able to keep up the energy saving behaviors. However, the incentive of the energy battle was gone and with it the social pressure.

Concerning the research question of this study - How did the Energy Battle influenced motivation, ability and actual energy saving behavior during and after the competition? – we can conclude that the Energy Battle had a big effect during the Energy Battle on the levels of energy consumption. The overall savings were 24%, with a maximum of 45%. The activities that were undertaken to save electricity ranged from individual actions such as turning off lights and cooking shorter or less (especially kettles) to social activities where household would eat together by candle light and coordinate computer use.

The combination of the Energy Battle elements had the desired effect on energy consumption. Main motivators for saving were the real-time feedback, dashboard with feedback over time and the competition between households. The feedback enabled the participants to learn about the consequences of devices use on the energy consumption. The tips contributed to this as well in some of the households.

The lower levels of energy consumption were not maintained on the long term, probably because the incentive and social dynamics of the Energy Battle were removed and the teams stopped with behaviors that were not comfortable. If there are lasting changes in behaviors they are probably changes in habits. We did however not obtain very detailed data about this.

7. Future research

Little is known about how games can stimulate energy behavior on the short, let alone on the long term. This study shows promising results for the long-term effects. Future research is however needed with a larger sample size and different types of households. Issues to address are:

- The balance between extrinsic motivation such as prizes and social pressure and intrinsic motivation to save energy.

- Ways to focus behavior on significant energy saving behaviors.
- Ways to achieve long-term effects such as habit formation and purchase behavior.
- The potential of stimulating extreme behaviors in a competition to lead to different ways of doing that consume less energy (social practices).
- Monitoring of habits and habit formation through the game design.
- The effects of the elements of the games (competitions) on the results of the games, for optimization of product and game design in terms of effect, cost and effort by participants and organizers.
- The implications for game design and effect on energy use of inclusion of renewable energy production on household or neighborhood level.

Currently a second research pilot of the Energy Battle is being set up. Approximately 80 family households will participate. The houses are equipped with smart meters, so that gas and water consumption can also be included in the game. The study will be executed in parallel to the pilot and address the above-mentioned issues.

8. Conclusion

The Energy Battle with its combination of real-time energy consumption feedback-dashboard, tips and competition had big savings as a result during the game, overall 24% with a maximum of 45% As soon as the competition was over energy consumption went up for most teams, though it tends to stay below the level of before the Energy Battle. For the effects on the long term, the study indicates that the participants formed habits for saving electricity. A definitive conclusion about the savings on the long term can however not be drawn due to the small sample size. This study indicated directions for further research into games as a means for behavior change amongst others the monitoring and facilitating of habit formation for long term effects.

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