Research Protocol for Technology Evaluation

**Abstract**

**Since the world population continues to grow, the importance of energy efficiency is getting dire. In order to achieve a better efficiency, the people of the world need to be informed of their energy usage in order to change their behavior in this regard. Many ICT systems exist to do exactly this. However, there will always be a challenge to provide appropriate feedback to the end users with varying knowledge, technical abilities, and motivation. This report will take one of these ICT systems, namely *emoncms*, and tailor the graphical user interface for the CoSSMic participants located in Konstanz, Germany. The extension of the GUI will include an update on the look and feel of the project website. But more importantly it will include a number of behavior change elements along with a gamification element. These additions to the CoSSMic to increase the awareness, motivation and behavior**

**This research plan will introduce an extension of the graphical user interface of the *emoncms* *energy monitoring system* and it will introduce a it will previous ICT systems which measured the consumption in an household, and served as a motivational tool to reduce energy consumption, with a gamification element. By combining the strengths of previous systems, and the game aspect, it is believed to have a great impact on the motivational influence the system has on the residents in the household. This report proposes a case study, followed by an experiment in order to determine the difference between the two types of ICT systems previously mentioned.**

# Study Description

## Study Question

Practical problem: People do not use energy in a smart way.

* People do not use PV electricity in an optimal level
* Consumers do not know how much their electrical expenditure is (?)
* Consumers are not aware of others consumption either (?)
* Problem concerning similar habits of users
* Peak hours are created because of these habits

How to use energy in a smart way? Creating an easier situation for producers during peak time.

What will be the effect of proper feedback related to energy usage (habits)?

* What is the proper feedback?
* Will the expenditure decrease as a result of information by the system?
* What kind of usage do we focus on? Total usage vs. related usage. E.g. avoiding peek time.

**Research questions (Why):**

We want to find out if “The CoSSMic Forest” makes it more motivating to better the habbits regarding reducing energy expenditure, the timing of the expenditure, and the optimization of different systems installed in the households.

* *RQ 1: How will this ICT compare to similar systems used in existing research?* 
  + *Considering the duration of the thesis, this is not viable anymore.*
* *RQ 2: How will the system change the daily routine of the user(s) in regards to when they use energy?*
  + *Quantitative data analysis with logs displaying the time and duration of use.*
* *RQ 3: Which of the elements of the ICT is most motivating?*
  + *Or: Which part of the game was most motivating?*
  + *Qualitative data analysis with surveys or interviews.*

**Research questions (revised 27/1/15):**

Evaluation of the game and the changes in behaviour it introduces. Proper feedback is still key, but use the competition aspect of the game in greater sense. The competition will be based on energy efficiency and optimization of the PV system usage.

* RQ1: How will the game influence the participation in the project?
  + Does the feedback and positive/negative reinforcement result in higher flexibiliy towards scheduling and timing?
  + Historical improvement?
* RQ2: What parts of the game is most motivating?

**Secondary objectives:**

How does the system/game compare in regards to previous systems used in previous research?

**Study design (how):**

## Rational, previous studies on the subject

**Intro**  
The motivation for this study is to get people to use energy in a smarter way. This does not imply to lower the electricity bill, but rather to use less electricity when the demand is high. By utilising self-produced electricity during peak hours, one is able to influence the power grid in a very beneficial way. In order to achieve the desired effect, the users of the PV systems needs to be able to see when the demand is high and also in which way their expenditure habits are affecting the load on the grid. So by aiding the users to gain greater knowledge concerning their own, and their neighbours, usage, we believe that as knowledge grows, so does the interest and motivation to change. The key aspect of this study is to get the participants to change their habits so they use the self-supplied electricity during these hours. This will be achieved by using gamification.

**Motivation**

In order to design an effective persuasive system, one needs to have decent knowledge regarding the psychological aspect of motivation, and take this into consideration when designing the system. One needs to understand why human beings have different *levels* of motivation and what *orientation* the motivation are. The orientation concerns the underlying attitudes and goals that gives rise to an action. The most basic difference in motivation is *intrinsic motivation, which* refers to doing something because it is inherently interesting o r enjoyable, and *extrinsic motivation, which* refers to doing something because it leads to a separable outcome.

*Intrinsic motivation* is when a person is motivated to act for fun or challenge entailed rather than because if external prods, pressures or rewards. According to the article, the inclinations to take novelty, to actively assimilate, and to creatively apply our skills is significant feature for human nature because it affects performance, persistence, and well-being across life´s epochs.

*Extrinsic motivation* is founded by a set of four regulators; External regulation, introjection, identification and integration. External regulation means salience of extrinsic rewards. Introjection means to act upon your own ego. Meaning that you focus on approval from others. Identification means that a person has identified with the personal importance of a behaviour, thus accepting its regulations as its own. Integrated regulation is when identified regulations have been fully assimilated to the self. This motivation type is ruled by the social psychology.

**Fogg**  
In order to achieve habit change in the users, it is important that the users are prompted with the appropriate feedback from the system. B.J. Fogg´s persuasive technology principles and motivation theory suggests that a combination of stimulating the intrinsic and and extrinsic motivation is needed in order to change ones habit. In addition to this a subject needs to be sufficiently motivated before the intervention, he/she needs to have the ability to perform the behaviour, and be triggered in order to perform the behaviour. More on Fogg´s theory

**Behavioural change**

The success of a persuasive technology is heavily depending on consumer’s participation and acceptance. These systems are created to aid a user to change their behaviour. According to B. J. Fogg, in order for a individual to adopt a target behaviour they need to be (1) be sufficiently motivated, (2) have the ability to perform the behaviour, and (3) be triggered to perform the behaviour [3]. In this paper Fogg proposes a model (Fogg Behavioural Model) that helps researches and designers to think more clearly about behaviour. It is important to see how all of the three parts has to be present in order for a change to behaviour to take place. In regards of the goal and research questions, it is important that the users involved in the research has an underlying motivation to use less energy. This might be of economical, environmental, or social reasons. The users have to be able to take the necessary steps to save energy. For example they need to be able to operate the thermostat in order to turn it down a few degrees. They need to be prompted by the system when an event take place, notice the trigger, and act according to the target behaviour. This can be in the form of an alarm that sounds, a text message, or an email. It is vital that the trigger happens at the most opportune moment. Or else the users might be discouraged or even angry, thus resulting in discontinuation of the system.

**Feedback**

A case study conducted in 1979, showed that by providing the households with real-time feedback of their consumption, they managed to reduce the consumption with between 10-15% [4]. Although old, this article it is very relevant to the ICT in mind. The study took place in suburban Maryland townhouse community near Washington, DC. from January to May 1979. 45 of the participants were randomly assigned to a feedback, self-monitoring, or comparison group. In the feedback group, the participants received a feedback sheet on the door for 28 consecutive days. Each sheet was colour coded, and had an ascending series of smiles or frown according to the prior days spenditure based on the base line consumption. The self-monitoring group got extensive training and practice with reading the dials of the house electricity meter. They got a sheet in the door every day, which contained the expected spenditure bared on the base line consumption. During the intervention and the follow-up period the feedback group and the self-monitoring group has managed to reduce their electricity by 13% and 7% respectively compared to the comparison groups.

The feedback provided was of a very simple nature, namely colours and smiley-faces. Although not very technically sophisticated, it certainly managed to motivate the users to use less electricity both during the intervention and the follow-up period. In this particular study the participants were subject of conditioning through positive or negative reinforcement, the feedback created awareness and knowledge towards their spenditure, possibly goal setting (intristic motivation [2]), and possibly a challenge between the neighbours (extrinsic motivation [2]).

A meta-review of the household electricity-saving opportunities conducted in 2010, which reviews several initiatives concerning electricity-savings, state that using real-time feedback will reduce the electricity consumption on average by 12% [5]. The articles also says that the feedback level which is most effective is the real-time, appliance level feedback. However, feedback alone is not enough to maximize the energy savings of a household. Instead, the most effective form of feedback includes both products (meters, displays, and other devices) and services (compilation of data, targeting and tailoring recommendations, etc). The effect of the feedback can be empowered by the use of goal setting, commitments, competitions, and social norms.

**Goal Setting with self-monitoring**In the literature review conducted in the early stages of this study, a majority of the articles read, reported that setting goals in addition to being able to monitor the gradual progress towards the goal, was most motivating for the users of the various systems. This is a key point we want to include in our system, in order to get a higher adoption rate and continuous usage among the users. More

**Social features and gamfication**

According to the afforementioned meta-review, one study that took place in California where 271 households participated, showed that out of the feedback messages received, the one containing information about the neighbours consumption was most motivating and had the greatest effect on the reduction of spenditure [5]. Furthermore, the review reported great energy savings in a case study at Oberlin University, Ohio. This study was conducted as a competition between 18 dormitory buildings at campus over a two weeks duration. The buildings were fitted with an aggregate, real-time feedback system, where the student could check their spenditure and the leaderboard online. This study resulted in a average saving of 32% across campus, where the winning dormitory managed to save 56% [5]. What is interesting is that the attendance for the reward meeting after the competition was concluded, was very poor. This points out that it was the competition that was the motivating factor for the great success, in addition to the newly formed social norm.

Gamification is a concept that makes a non-game context into a game. This has proven to be a very powerful tool in order to engage users in a more effective manner. By combining the gamification aspect with competition, one might be able to create a very intriguing social experience for the user, which will prolong the duration of usage. This is relevant when it comes to our research goal. By adding gamification elements to the ICT system, we will create an arena where the neighbours are challenging each other to save the most, namely through the game.

**Identification of research gap**Use gamification in addition to feedback, goalsetting etc. Need more

## Objectives, hypotheses and aims

Since the system is installed prior to the intervention of the game, we are able to get data on behaviour prior to the game is presented for the users. This will shed some light on how the game is affecting the usage of the systems and the behaviour after a period of using the system. Our hypothesis is that the game will increase the effectiveness of the energy expenditure, and change the behaviour of the participants.

What we want to see as a result is a more efficient user, who uses the self-provided energy in a more efficient matter. This will have a positive effect on the amount of watts spent in the household.

## Design and methods

### Study design

Qualitative vs. quantitative –

Survey

Case study

Evaluation study / experiment – The change when the game is introduced

#### Description of Technology to be Evaluated

#### Level of maturity required from the technology to be tested

#### Alternative technologies

### Study population

General population? Tech-geeks? Demography – income,

### Sample size and statistical power

The subset of populations

Case study – one family is enough

### Subjects: selection and definitions

The six families in Konstanz, because of Germany

### Data collection methods: measurements, definition

Questionnaire, interviews, phone/skype etc.

### Data management and statistical analysis

Mapping, coding,

## Project management

### Personnel required

### Duration of the study (timeline)

How long will we observe the participants?

### Follow-up procedures (if needed)

Reuse of the system

## Strengths and limitations

The limitation as of now would be the short duration of the project. We will not be able to follow up and see the actual changes in behaviour in regards of our goal. In order to make a conclusion whether the system/game has been improving the energy efficiency, it is necessary to observe the habits before the intervention, during the intervention and post intervention. The longer the observation study, the more accurate data will be gathered.

## References

# Ethical consideration

It is okay to store the user data as long as it is kept within the project. Server hosted at SINTEF for example. Need to clear with NSD.

# Significance (or expected impact)

# Budget

# Investigators: role of each and curriculum vitae