10.20378/irb-58497

Promoting Energy-Efficient Behavior by Recommendations based on Energy Cultures

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Abstract. Enhancing people's energy behavior is an important research topic. We aim to support people by recommending specific energy-saving actions when they have the opportunity to save energy. To persuade people to execute the actions we incorporate findings of models related to behavior change into the system's decision making process. In this paper, we consider how the idea of Energy Cultures can be integrated into a recommender system and present results of an online survey that investigates the effect of users' Energy Culture on their preferences for energy-saving actions.

1 Introduction

For several decades research investigates how people's energy demand can be reduced [2]. Developed approaches include the provision of detailed feedback on people's energy usage [5], persuasive games [6], and systems, such as smart thermostat controls [8], which automatically measure and control the energy consumption. However, people still lack accurate and easily accessible information on how they could achieve potential savings through own actions [7]. Benders et al. [1] showed that the best results can be achieved if people receive useful and personalized advices that they are able to perform, and that they can trust. Ford et al. [4] developed a web-based system that provides personalized advices based on the users' preferences for specific criteria, such as monetary costs, time costs, or the effect on their comfort, reporting promising results in first tests. In contrast to Ford et al.'s [4] conversational recommendation approach that provides recommendations only if users are searching for them, we aim at developing a system that is able to recommend energy-saving actions whenever users can save energy, without prior interaction. For example, the system could remind people of switching off the

light if they leave a room over a longer period of time, or it could recommend buying more energy-efficient devices if the users have the financial means.
Since such actions often entail crucial changes to users' habits, the system needs to provide certain sensitivity in persuading people to execute the recommended actions. Therefore, it could incorporate the findings of models on behavior change [3,10] (Section 2) into the systems decision making process. The main contribution of this paper is an investigation of the Energy Cultures Framework [11]. It describes criteria by which people's energy behavior can be characterized and thus identifies target points for actions by which people could be supported in enhancing their behavior on a long-term basis, see Section 3. In order to find out, whether the framework can be incorporated to enhance our recommender system's ability to choose suitable energy-saving actions, an online survey was conducted to gain insights into different Energy Cultures' preferences for energy-saving actions. The design and results of this online survey are presented in Section 4. The last section concludes the work and presents future work.

2 Behavior Change

According to *Fogg's Behavior Mode*l [3] behavior changes are affected by three factors: people's *motivation* and *ability* to execute a given task, and the *trigger* to take action. A persuasive recommender system therefore should only recommend actions that users are able and also willing to perform if they are motivated by the system. Thereby, even a person with a low motivation could be persuaded to apply an action if the trigger presents an action that can be executed easily enough. The right time to provide the trigger could be chosen by a context-aware system that proactively and immediately provides recommendations whenever users are able to make use of them.

In comparison the *Transtheoretical Model (TTM)* [10] describes behavior change in five stages: First people are unaware, and unwilling to change their behavior (*Pre-contemplation*). Then they acknowledge their problems, are open to information about the problem behavior, and intend to change their behavior in the future (*Contemplation*). *Preparation* is the stage in which people are ready to change their behavior in the near future and thus plan actions. Then they take *Actions* to change their behavior. Finally, they try to sustain changes and to prevent relapses (*Maintenance*).

In summary, a persuasive recommender system for energy-saving actions should only provide recommendations that fit the users' *motivation* or *stage of change* as well as their *abilities*. While less motivated people should be provided with actions, such as “Turn off devices instead of leaving them in

stand-by mode", more energy-aware people with the possibility to go to work by bike or by public transport could get the corresponding recommendation. In order to understand and analyze the origin of people`s energy behavior a system could incorporate the Energy Cultures Framework [11].

3 Energy Cultures Framework

According to the Energy Cultures Framework [11], people's energy behavior is influenced by three major factors: People`s *material culture* describes their properties and surroundings, such as their home`s insulation or the possession of different means of transportation. However, these properties are not only rated by their number, but mostly in terms of energy efficiency. The factor *norms* summarizes people's attitude towards the topic “energy saving" by considering whether energy saving is an important issue for them in general and by considering their specific opinions, e.g., an adequate room temperature. Finally, persons' executed *energy practices* describe their actual behavior, such as the current energy consumption, or heating habits.

The factors also influence each other. For example, a good insulation (Material Culture) leads to a decreased need for heating (Energy Practices) and the resulting savings could motivate people to save even more energy (Norms). The factors also can be influenced by external actions such as laws or, e.g., an increased price of electricity. However, it is ineffective to develop only uniform approaches or guidelines to foster changes of people's energy behavior, since attitudes and prerequisites inside a population are very heterogeneous [11]. We aim at tackling this issue by a personalized recommender system.

To summarize, incorporating the Energy Cultures Framework into a recommender system, based on Fogg's Behavior Model, seems to be a good approach to develop a persuasive system that fosters energy-efficient behavior. While knowledge about users' material culture and already executed energy practices could facilitate the choice of applicable, but also serendipitous recommendations, users' norms along with their already executed energy practices could be an indicator for their level of motivation and thus also the acceptable difficulty of recommended energy-saving actions.

4 Online Survey

In order to evaluate whether users' preferences concerning energy-saving actions depend on their *(cognitive) norms*, *material culture*, and their already performed *energy practices* we conducted an online survey.

4.1 Method

The first part of the study (22 questions and statements) was aimed to collect information by which the participants could be clustered regarding their energy-cultural background. These questions were based on a detailed description of characteristics of four major Energy Cultures that were identified by Lawson et al. [9]: Energy Economic, Energy Extravagant, Energy Efficient, and Energy Easy. The statements had to be rated on a 5-point Likert-Scale from “not at all" to “in any case". The participants' norms were assessed by their answers on statements, such as “I don't worry about energy-saving.", “Saving energy is important. However, so far I perform only a few energy-saving actions." or “I really watch my energy consumption." It was also considered whether participants save energy to protect the environment. To assess participants' material culture they had to rate their home's insulation from “very bad" to “very good". Additionally, they had to state the utilized type of heating system, the number of household appliances, the number of cars and motorized two-wheelers, and the number of bicycles. Afterwards a per capita value for the amount of possessed things was calculated and all facts were rated regarding their energy efficiency.

In the second part of the survey the participants were confronted with 21 energy-saving actions that were compiled based on tips on energy-saving provided by the WWF[1], and the German BMUB[2]. They included changes on the buildings, buying more energy-efficient devices as well as changes to the users' behavior, see Table 1. They differed, amongst others, in terms of temporal as well as financial expenditure, and eventual inconveniences for the users. The participants had to rate their interest for the specific actions as well as their willingness to execute them on a 5-point Likert-Scale from 1 = “not interested/willing at all" to 5 = “very interested/willing". To access the participants current energy practices an additional option was added, 6 = “already applied".

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1 http://www.wwf.de/aktiv-werden/tipps-fuer-den-alltag/energie-spartipps/stromsparen/

2 http://www.bmub.bund.de/themen/klima-energie/energieeffizienz/foerdermittelberatung/energiespartipps/

4.2 Results

In total, 32 women and 58 men took part in the survey. They included very heterogeneous people with different demographic backgrounds: (A) Young (21-30), unmarried students, on lower incomes, living in a rented flat or apartment, or in shared flats in a middle or big city; (B) Middle aged (31-50), married, unmarried or divorced, partly with children, working in all kinds of profession, on average incomes, living either in owner-occupied houses in more rural areas or in rented flats or apartments in big cities; (C) Older than 51, married, children that have often already moved out, working in all kinds of profession, on average to high incomes, living in middle to smaller cities or in rural areas, mostly in houses, either owner occupied or rented.

(1) • Air rooms periodically with windows fully opened instead of continuously with tilted windows • Turn down the heating in unused rooms • Turn off lights in unused rooms (2) • Vent radiators regularly • Close shutters or curtains to keep the temperature constant • Install energy-efficient lamps • Line-dry laundry outside • Change the refrigerators temperature setting to 7° • Turn off devices instead of leaving them in stand-by mode • Go by bike or by foot more often	(3) • Install draught stops around doors and windows • Replace/upgrade windows • Install smart or programmable thermostats • Replace appliances by more energy-efficient ones • Pull the plug of unused appliances • Use public transport more often (4) • Install/upgrade wall insulation • Install heat-reflective mats behind radiators • Replace/upgrade your heating system • Buy a hybrid or electric car • Do car sharing

Table 1. Collection of energy-saving actions clustered by the survey's results

First, participants were clustered depending on their material culture, their norms, and their energy practices. For each factor we calculated the participants' proportion of positive answers in comparison to the total amount of questions considered for the specific factor. Proportions higher than 60%

were assigned a positive appraisal. Proportions between 40% and 60% were rated neutrally, and proportions less than 60% were rated negatively. The distributions of the ratings for the three factors describing Energy Cultures are shown in Figure 1.

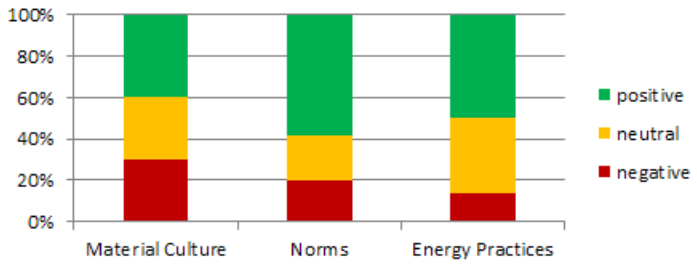

Figure 1. Assessment of the participants' material culture, norms, and energy practices

The actions could be categorized into four groups, see Table 1: (1) Well-known actions that most of the participants already are used to execute. (2) Actions that have already been applied by approx. half of the participants. Additionally, many of the remaining participants (40-70%) are interested and also willing to execute these actions. (3) Actions that approx. a third of the participants already perform, with approx. another third being interested in or even willing to perform them. (4) Actions that were executed by only a small number of participants (1-20%) and that also most of the participants were not interested in or willing to execute.

After categorizing participants as well as actions the provided mean ratings per category of participants were analyzed by a descriptive analysis to get a first impression of whether differing categories also had different preferences, see Figure 2.

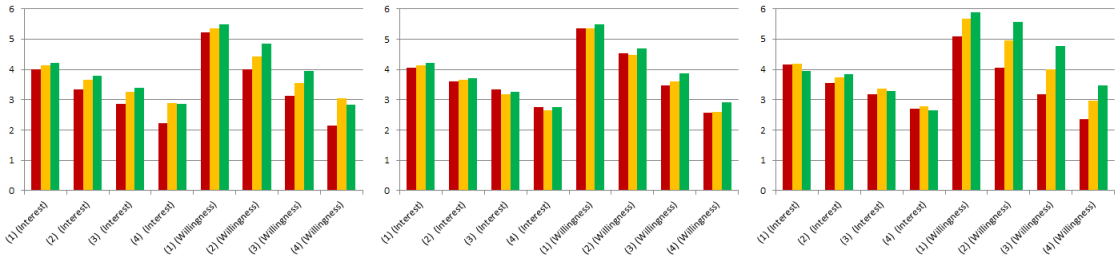

Figure 2. Mean ratings for actions of the categories (1) - (4) provided by members with a positive (green), neutral (yellow) or negative (red) appraisal for the investigated Energy Cultures factor: Norms (left), Material Culture (middle), Energy Practices (right)

The mean ratings of participants with differing norms showed differences in the groups' interest in specific energy-saving actions as well as their willingness to perform them. Participants with energy-friendly attitude in parts showed more interest and willingness than participants with negatively

assessed norms, especially concerning less popular energy-saving actions. Concerning the material culture, mean ratings of the participants showed only small differences. However, participants that already had a good material culture were more willing to apply the presented actions. Whether people already applied a lot of energy practices or not, had no effect on the mean ratings concerning their interest in the actions. However, since a positive appraisal concerning the criteria energy practices was based on a large number of already performed energy practices there was a major difference concerning the people's mean ratings related to their willingness to perform the recommended actions.

4.3 Discussion

A first analysis of the survey's results showed that people with a differing energy behavior have differing preferences for energy-saving actions. We think that by categorizing users into groups of people with a similar energy-cultural background, the system's decision-making process could be enhanced. For example, the survey's results let assume that users that already perform a lot of energy practices showed less interest in several of the presented actions because they already knew and applied them. Therefore, they should be provided with serendipitous recommendations. In contrast, people that perform only a few energy practices seemed to be not interested in several of the actions because they actually were not willing to perform them. This was especially apparent for actions that required higher monetary or timely costs, or that affected their comfort. They should be provided with actions that are easy to perform. In contrast, people with energy-friendly norms could be persuaded to apply actions that require more effort. Another advantage of incorporating the concept of Energy Cultures is that the system could be enabled to react to the users' behavior change by adapting the user models stepwise based on users' reactions to previous recommended actions.

5 Conclusion

We presented an idea of a recommender system that is aimed to foster energy efficient behavior by recommending personalized energy-saving actions. We aim at developing a system that provides only recommendations that fit the users' current state of change, motivation, and abilities. As a first step, we investigate whether the concept of Energy Cultures [11] could be a useful approach to model users' energy behavior including their motivation and

ability to apply different kinds of energy practices. A first analysis of an online survey's results showed promising results. In the near future the data gathered in the survey will be analyzed more in detail and a recommender system will be developed that utilizes the concept of Energy Cultures to provide feasible, useful and interesting recommendations to support people in enhancing their energy behavior.

Acknowledgements

This research is related to the IT4SE project, funded by BMBF. For more information visit http://www.it4se.net.

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