Leveraging Gamification in Demand Dispatch Systems

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ABSTRACT
Modern demand-side management techniques are an integral part of the envisioned smart grid paradigm. They require an active involvement of the consumer for an optimization of the grid’s efficiency and a better utilization of renewable energy sources. This applies especially in so called demand dispatch systems, where consumers are required to proactively communicate their flexibilities. However, a monetary compensation may not sufficiently motivate the individual consumer for a sustainable participation in such a program. The proposed approach uses a motivational framework leveraging the novel area of gamification, which applies well-known game mechanics, such as points and leaderboards, to engage customers in the system. This is accomplished by embedding a special scoring system and social competition aspects into a stimulating user interface for the definition and management of flexible energy demand. In a first user study, the system showed a high user acceptance and the potential to engage consumers in participation.

Categories and Subject Descriptors
H.1.2 [Model and principles]: User/Machine Systems—Human Factors

General Terms
Design, Economics, Human Factors

Keywords
Smart Grid, Demand Response, Direct Load Control, Demand Side Management, Sustainability, Gamification

1. INTRODUCTION
Continuous balancing of energy demand and supply is a fundamental prerequisite for the stability and efficiency of energy grids. Due to the change of the energy market from a day-ahead market to a continuous intra-day trading with dynamic interactions between market participants, the balancing task becomes more difficult. This market liberalization in combination with the increased support for smart meters requires fine-grained planning capabilities. In addition, the increased integration of renewable energy sources (RES, e.g., wind, solar) poses additional challenges and requirements, due to their heavy dependence on external influences such as weather. Thus, in contrast to traditional energy sources, they are hard to plan and predict. It is also very inefficient to store energy from RES and thus, the generated energy has to be directly used when available. As a result it is necessary to balance energy demand and supply in a fine-grained manner and to establish possibilities for real-time balancing.

In the EU funded research project MIRABEL we address the issue of real-time balancing by developing a conceptional and infrastructural approach that allows a more efficient energy management and to utilize a higher amount of RES. The core idea is a demand response system where market players may express acceptable flexibilities for their energy demand and even specific supplies. The execution of these requests can then be scheduled within their given flexibilities to allow fine-grained balancing. Upon execution, devices connected to their requests are automatically started using the currently emerging smart metering technology. This type of demand response approach is also referred to as demand dispatch [2]. With the help of this concept, renewable energies can be better utilized by dispatching demand when energy from RES is available. Also, cost savings are possible by smoothing cost-extensive peaks or executing demand requests while cheap energy is available.

To allow innovative demand response concepts, as developed within the MIRABEL project, to work, an active participation of customers is one of the most crucial prerequisites. The reason behind this is that for most types of consumption, preferences have to be actively submitted by the customers. In present realizations usually monetary incentives are applied to motivate consumers to participate. However, since the benefit of an individual participating customer is relatively small for the BRP, also the incentives for the participants are rather small. The revenue for a 'smart' washing machine, e.g., is estimated at under 8 EUR/year [15]. For this reason, the employment of other techniques for motivating customers in actively defining their flexibilities is needed.

In this paper we present a demand response approach that relies on motivation techniques from the uprising research area of gamification. Gamification utilizes the design patterns and dynamics of games to enrich user experience and to engage users in otherwise pragmatic products [4].
Figure 1: A demand flexibility with its attributes and its impact on the grid's imbalances. a) imbalances without leveraging demand flexibilities; b) imbalances reduced by demand shifting;

Our work makes the following contributions, which also reflect the structure of the paper: 
First, we outline general aspects of motivation theory and gamification and their possible use in demand dispatch systems in Section 2 and 3. 
Second, in Section 4 we present the user interface and interaction processes within our demand dispatch system approach. In addition, we also describe our scoring system that forms the basis of our gamification approach. 
Third, we illustrate the results of our evaluation in Section 5, which show that our approach offers a high user acceptance and the potential to motivate customers in participation. 
Finally, we present related work in Section 6, future work in Section 7 and conclude the paper in Section 8.

2. MOTIVATION AND GAMIFICATION

To employ a framework for consumer engagement in defining flexible demand, a deeper look on motivation theory is needful. In self-determination theory, two types of motivation are distinguished: extrinsic and intrinsic motivation [14]. Extrinsic motivation is created when a certain purpose is pursued with the related behavior. This includes monetary rewards or the prevention of punishments, but can also be caused by external regulations or personal importance. Extrinsic motivation is regarded as a highly reliable technique for behavioral change. However, external incentives do not bear the potential for durable influence on behavior and its effects vanish immediately when the application is stopped. Intrinsic motivation, on the other hand, emerges if the behavior itself provides the respective causes of engagement. This primarily corresponds to the human tendency "to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn" [14]. While the effects of intrinsic motivation are particularistic and cannot easily be foreseen for each individual, a strong engagement on long-term can be achieved in general [3]. Nonetheless, under certain circumstances also intrinsic motives can be diminished or canceled out. While positive performance feedback enhances intrinsic motives, they are reduced by negative feedback. Furthermore, the application of external incentives can crowd out intrinsic motivation, which is known as motivation crowding [6]. Especially tangible rewards were found to reduce intrinsic motives, whereby the pursuit of earning rewards eliminates further engagement beyond this cause. Thus, intrinsic and extrinsic motivation usually can not easily coexist for the same behavior. 

The establishment of intrinsic motivation can be achieved through numerous strategies. McGonigal [12] proposes a categorization of four major types of rewards leading to intrinsic motivation: Satisfying work resulting in a directly recognizable effect of made efforts, experience or hope of being successful while engaging in a learning process on how to continuously achieve better results, social connection as the human need to share thoughts and perform tasks with others and the abstract term of meaning, describing the intrinsic reward of being part of something larger than oneself, such as the pursuit of a hard to achieve collective goal.

In traditional work environments these factors only play a minor role and effort usually is compensated by extrinsic rewards. This is different in games, which are played merely for intrinsic rewards. Especially the recent success of online multiplayer games, such as World of Warcraft, proved that an intense engagement in a product or an activity can be created without giving any extrinsic incentives. The difference between games and productive software can be identified in their hedonic and pragmatic qualities [9]. Pragmatic attributes refer to a software's usefulness and determine how clear, supportive and controllable the product is perceived, regarding its functionality. The hedonic attributes of a product, on the other hand, are described by the ability of a product to evoke emotions in the user, such as excitement or pride. While pragmatic qualities address the fulfillment of certain goals, hedonic qualities emphasize a psychological well-being and stimulation of the individual. The intentions for using pragmatic software lie in the extrinsic motives of pursuing a goal, while hedonic products are used 'for the sake of it' and, thus, out of intrinsic motivation [17].

The novel paradigm of gamification proposes to combine both types of qualities to establish an engagement in software products with pragmatic intents. Therefore, gamification establishes intrinsic motives by utilizing the heuristics, design patterns and dynamics of games to enrich user experience and to engage users in the addressed product [4]. In practice, gamification is applied by the employment of well known game mechanics, such as point systems, levels and badges, as a foundational framework for a system of intrinsic rewards. Point systems, for instance, are considered as an “absolute requirement for all gamified systems” [19] and to build up a foundation for measuring a user’s progress and performance in activities with the product. Dependent on which aspects of the product the point system is supposed to support, several distinct variants of scoring systems can be applied, ranging from simple ‘experience points’, earned for performing specific actions, up to ‘reputation points’, which can be assigned from user to user. Two other important game mechanics which are applicable on non-game products are represented by levels and badges. In games,
levels indicate the proficiency of the player in the overall gaming experience over time and may also mark a certain progression of difficulty. This scheme also serves for serious contexts, for instance to indicate a user’s knowledge of the regarded product and the extent to which the user has been engaged in it. Badges serve similar purposes, although they signal progression by being rewarded for the completion of distinct goals. Additionally to indicate status, badges leverage the drive of collecting and may also be appealing in an aesthetic sense, considering a badge as a trophy-like item to appreciate simply for the particular success it is representing [19]. Enriching serious software with game mechanics adds their hedonic qualities to the product’s pragmatic attributes which creates a broader overall user experience. Therefore, the transferred hedonic aspects from games are not necessarily limited to the above mentioned elements of points, levels and badges, but may also include other typical attributes of games, such as stimulating visuals or novel input techniques.

3. GAMIFYING DEMAND DISPATCH

In a demand dispatch system, consumers should become encouraged to cover as much of their everyday energy demand as possible with timely flexibilities and to define these flexibilities as long as possible. Furthermore, participants need to be engaged on long-term to ensure a sustainable and efficient continuation of the program. This approach utilizes an intrinsic motivational framework to engage residential energy consumers in demand dispatch programs. The essential idea behind this approach is to encourage the exposure of one’s consumption habits by making it an interesting and enjoyable task, and thus to establish a deep and long-term engagement in the system.

To accomplish this, we propose a motivational framework, oriented towards McGonigal’s intrinsic rewards, consisting of four aspects to incorporate in an engaging interface between consumer and BRP: An optimization of the system’s user experience, especially regarding its hedonic qualities, a scoring system, rewarding the quantity and quality of submitted flexibilities, social competition against other consumers and an inherent highlighting of the system’s pro-environmental background.

Satisfying work – The user experience of an interactive system greatly influences the motivation of its users. To take a positive effect on the user’s engagement, especially on long-term, a system has to not only be perceived as useful or easy to use, but also enjoyable and exciting. Thus the overall user experience of a demand dispatch system should be maximized by enriching its pragmatic attributes with hedonic aspects. This includes an attractive user interface with stimulating visuals and exciting interaction concepts, as well as a high degree of usability. Designing the system towards a satisfying work experience for the user, frustrations should be prevented and a direct feedback on the user’s actions has to be established.

Experience of success – To provide feedback, the system has to reward the user’s actions according to their effort and impact. This is established by a scoring system, rewarding submitted consumption flexibilities with so called EarthSaver Points (ESP). For each submitted flexibility, the consumer is rewarded a specific amount of ESP, dependent on its attributes and impact. This amount is determined by three major factors: The direct impact the dispatchable demand takes on the grid’s balancing, the potential impact the flexibility bears to cope with unforeseen effects and the energy efficiency of the actual consumption. The direct impact is identified while looking up the optimal position for the consumption in the schedule. When a scheduling position is found, the direct impact on grid optimization is derived from the benefits this shifting of load is assumed to cause. The potential impact, on the other hand, describes the alternative possibilities to use this flexible demand besides the initially determined scheduling position. This especially plays a role when unforeseen external effects occur and the grid’s changed load profile requires an adjustment of the dispatch arrangement. Ultimately, this factor is determined by the actual length of flexibility given, derived from the earliest and latest start. The energy efficiency factor of a specific consumption essentially reflects the eco-friendliness of the addressed appliance mode. This value depends on the chosen run mode, so ‘eco-modes’ are set to earn more points than traditional run modes with a larger energy consumption. Figure 1 depicts these three factors to calculate the value of flexible demand and by which attributes they are influenced. While the direct impact is influenced by the proposed period of dispatch, this again depends on both, the position of the flexible period in time and its actual length. Thus, the length of flexibility not only influences the potential for alternative scheduling positions, but also the assumed impact during submission.

Social connection – To bring social aspects into the system, users are able to compare their performance to the performance of their friends or other people with a similar household size. This creates additional motivation on several levels. First, it is possible to compare one’s performance with the average user. This creates a normative social influence on the user, which is considered to positively take ef-
fect on behavior, especially regarding pro-environmental issues [7]. Second, one-on-one comparisons can be employed, putting the user in direct competition with participating friends. This type of comparison was found to be a very effective instrument for behavioral change, also on the long-term [16]. In practice, this comparison may be implemented through challenges between individual users or by employing performance driven leaderboards.

**Meaning** – The essential background of a demand dispatch system is to optimize energy supply and demand for a better integration of renewables and less CO$_2$ emissions. This creates a meaning for one’s participation in such a program, making the user part of a broad initiative towards ecologically aware behavior. To leverage this circumstance, the pro-environmental aspects of the system should be inherent throughout the product, as perceived by the user.

4. **A PROTOTYPICAL USER-CENTRIC DEMAND DISPATCH SYSTEM**

The proposed motivational framework was implemented in a prototypical demand dispatch system. To allow the user to convey her consumption flexibilities to the electricity provider, communication links between the two are established through a mobile user interface. With this application users may define their flexibilities and manage already submitted ones. Furthermore, the interface allows the BRP to negotiate flexibilities with the consumer. This becomes important when slight extensions of the flexible period are assumed to allow a far better grid optimization with the shiftable demand. To control the service, a data management system is installed on the utility side which receives submitted flexibilities and maintains an execution schedule, under consideration of the most beneficial exertion of the demand flexibilities. The impact of demand shifting for particular periods is therefore calculated using forecast data on demand and supply in the grid and market specifics, such as energy prices.

**Interaction Processes in the System**

The system’s main interaction processes between consumer and provider are presented in figure 2. After being submitted in the *definition* phase, a demand flexibility may pass several *rescheduling* runs before it is *dispatched*. During this process the BRP-side may negotiate or renegotiate the flexibility with the customer.

**Definition** – When a consumer defines a new flexibility, it is initially submitted from the user interface to the management system where it is evaluated regarding its optimal placement within the overall schedule. If the system detects a relevant surplus for scheduling the demand outside of the given bounds in comparison to the initially stated flexibility, a negotiation with the customer about an according extension is initiated. The consumer is therefore offered to shift the earliest or latest start of the related energy consumption to a more appreciated position for a specific amount of EarthSaver Points, or to decline the request and keep the flexibility period as initially defined. After the consumer decides on how to proceed with the extension request, the demand load is accordingly positioned in the schedule. The negotiation procedure is skipped if no worthwhile extensions for the regarded flexibility were identified. The demand is then directly scheduled without further interactions. After a demand load is scheduled, the moment of its dispatch is fixed until the respective point in time, or if changes in the underlying forecast data require a rescheduling.

**Rescheduling** – When a rescheduling is triggered, the over-
all schedule is invalidated. Thus, all pending loads are arranged towards an optimal profit over the whole influenced period while adhering the respective flexibilities. Furthermore, new extension possibilities are evaluated for each submitted flexibility. If worthwhile extensions are found, they are proposed to the consumer and the consumption is scheduled according the consumer’s decision. Although multiple rescheduling runs may occur during a demand flexibility’s life cycle, negotiation attempts are triggered only for higher benefits if the consumer was requested for extension earlier, to avoid an annoyance.

**Dispatch** – When the scheduling time of a pending consumption is reached, the according demand is dispatched and is no longer regarded in later (re-)scheduling runs.

**User Interface**

The user interface provides the means to create and manage demand flexibilities in a domestic environment. To further give intrinsic motivation to the consumer in using the system, especially user experience aspects, such as its hedonic qualities, are addressed in the interface design. This includes an attractive, clearly structured overall presentation and intuitive interaction mechanics. To obtain a single view on all major functions of the system, the main screen (see figure 3) is split in three parts: The **game area** where the user’s score, level and leaderboards are displayed, the **flexibility area** which presents the currently pending, running and historic demand flexibilities, and the **monitoring area** where charts on the historic consumption, a plan on the pending flexibilities or the predicted amount of renewable energy in the mix are displayed.

To submit a new flexibility, the **creation screen** is displayed, being the most interactive area of the user interface, shown in figure 4(a). Here, the consumer defines the appliance and its run mode to be executed, the earliest start time and the latest end time of the cycle. The appliance and run mode under consideration can separately be selected using dropdown boxes which are shown on a tap on the respective button. To configure the start and end times of the consumption flexibility, a time picker widget (represented by the green bar below the appliance and run mode buttons) is adjusted in respect to a horizontal time line, henceforth referred to as **dayline**. The dayline features various graphical indicators to support the user in the definition of the anticipated flexibility period. A synthetic sky background reflects the day’s progression according to each time step, by showing the altitudes of the sun and day and night transitions. This is supposed to raise the user’s efficiency in seeking the loose starting or ending period, before relying on the representation of time in numbers for the final adjustments. As an additional overlay, the dayline presents weather information, such as pictures of clouds, rain or snow to indicate the respective weather events for the related time steps. This feature allows to indicate the availability of certain renewable energy sources. Furthermore, the graphical presentation of the weather in conjunction with the sky may be visually appealing to the user. To indicate the user which appliances are already planned for flexible dispatch, the corresponding periods are marked with green bars in the area below the weather display. Below this area, the approximate amount of earnable EarthSaver Points in the regarded time steps is displayed by a vertical bar chart. The individual bars are realized as staples of green dots to embody the points to earn at the specific period.

After a new flexibility was defined and extension possibilities were identified by the scheduling backend, a negotiation dialog appears as depicted in figure 4(b). This dialog presents the worthwhile elongations to the user and a decision is requested on how to proceed. The presented options include the denial of extending the regarded flexible demand and actual extension offers proposed by the system. If multiple possibilities were found, the presented extensions are limited to two of them: The extension with the best ratio between gain of impact and extension length and the extension with the most impact. This limitation is introduced to not overburden the user with too complex decisions. To further support the user in deciding between the given options, visual hints indicate the relation of flexibility and score for each proceeding. These hints are realized as horizontal bar charts, showing the each option’s flexibility span and the points to be earned as single bars. The negotiation dialog is shown also when a renegotiation is initiated. In this case, the dialog is shown when the user responds to a respective notification, displayed in the upper right corner of the screen.

**Scoring System**

The backbone of our gamification approach is represented by a scoring system, which rewards an inherent and effi-
cient creation of consumption flexibilities. When a participant submits a new flexibility, she is rewarded a specific amount of ESP. These points add to an overall score, indicating the consumer’s performance in the creation of flexibilities around her everyday-life consumption. As mentioned above, the exact amount of points the submission of a flexible consumption is rewarded with is derived from its direct and potential impact on the grid and the load’s energy efficiency. The direct impact is calculated by comparing the overall costs in the period of potential consumption for the designated scheduling position \( s \) and for an assumed inflexible consumption. The inflexible consumption represents the occurrence of according demand under assumption that no timely flexibility was defined for it. In practice, an average over all possible scheduling positions is assessed, since the actual inflexible consumption is unknown to the system but certainly resides somehow inside the flexibility bounds. Since renewable energies are assumed to be available free of charge for the BRP, occurrences of RES in the mix are directly reflected in the cost model. To prevent a user discouragement if the direct impact is calculated comparatively low for periods in which no imbalances are predicted, a certain minimum impact is defined. Thus, the user may still be rewarded for the amount of offered flexibility, although the benefit for the BRP cannot be determined yet. The direct impact of a consumption dispatch scheduled at the time step \( s \) is denoted by \( I(s) \). Let furthermore \( e \) describe the energy efficiency of the regarded appliance mode and \( w \) the potential impact of the demand flexibility, represented by its actual duration. The value of a defined consumption flexibility \( f \) then results from

\[
\psi(f) = I(s_f) \cdot e_f \cdot \sqrt{w_f}.
\]

(1)

Since the cost reduction of a flexible consumption mostly correlates with its actual flexibility length, the slope of the score function declines for higher flexibilities to not overrate the combined value. When a flexibility is about to be negotiated with the customer, the score is partly recalculated. Therefore, the amount of negotiations \( n \) is introduced as an additional factor, so that successful requests for extension positively affect the overall score. Since the underlying data might have changed when a flexible demand occurs to need a renegotiation, a complete recalculation of the flexibility’s points might result in a worse score than the initial amount of assured points. Hence, the new value \( \psi^* \) is derived from the original value and the benefit from the flexibility. Let \( \Delta I(s_f^*) \) denote the gained direct impact through the extension, then the new value of the demand flexibility \( f \) is calculated as

\[
\psi^*(f) = \psi(f) + \Delta I(s_f^*) \cdot e_f \cdot \sqrt{w_f - w_f^*} \cdot \sqrt{\frac{n_f^*}{n_f}}.
\]

(2)

To ultimately determine the specific amount of ESP to reward the user, the value of \( \psi(f) \) (or \( \psi^*(f) \) for negotiations) is multiplied by a score multiplier \( m \):

\[
\text{Points}(f) = m \cdot \psi(f).
\]

(3)

The value of \( m \) has to be chosen so that a comparable score without significant decimals emerges. To balance direct and potential impact in the score, the energy efficiency values and the minimum direct impact are chosen corresponding to the general range of the direct impact.

Establishing the score as an indicator for the consumer’s performance in defining demand flexibilities, the related feedback appears on three stages. First, an estimation of the score the anticipated flexibility would earn is given while the user adjusts the time picker widget. Thus, the user is provided an initial orientation how much ESP are to earn in the specific periods. However, this is merely a temporary value, since the ultimate ESP are determined when the flexibility was scheduled by the system. This ultimate score describes the second stage of feedback, which is given directly after the user submitted a new flexibility. Thereby, an immediate feedback is given which adds also to a satisfying work experience. If her performance could have been better (i.e. extension possibilities exist), it is indicated immediately in the early negotiation and the possibility to ‘try again’ is provided by the given extension options. The third stage of feedback is represented by the indicated overall score of a user, incorporating an aggregated score to describe the user’s performance on long-term. The user is hence rewarded for continuously using the system for a number of flexibilities. As a coarse feedback on the user’s overall performance, a level is assigned, dependent on the ESP earned so far. When leveling up, certain external rewards can be given, such as low-cost items that are nonetheless valuable for the customer, as proposed by Zichermann [19]. To prevent motivation crowding, these rewards should be held relatively small at first and increase in value when a level-up occurs less often for the user. Additionally, each level is connected to a certain title that virtually describes the user’s engagement in the system so far. For the first level this might be “Consumption newbie”, while on higher levels titles such as “Eco Hero” or “Green Mastermind” may be applied. With each level, the amount of points to reach the next stage increases, so leveling up becomes harder in progressed stages.

5. EVALUATION

To evaluate the proposed user interface for the domestic energy consumer, a test on user experience and usability was conducted on twelve test subjects. First, the evaluation should reveal possible shortcomings in the design regarding the ease of use and practicality of the application, since the effort required to complete the essential tasks supported by the application takes an immense effect on the overall acceptance of the system as a product. Second, the appeal and attractiveness of the interface experienced by the user besides its pragmatic qualities should be examined. To assess additional quantitative data on these questions, the AttrakDiff questionnaire [10] and the System Usability Scale (SUS) [1] were applied after the usability test. The SUS measures the usability of an interactive system by a ten-item Likert scale, resulting in a one-dimensional score between 0 and 100. The AttrakDiff questionnaire is a semantic differential with 28 bipolar adjective pairs which measures the user’s attitude towards a system’s pragmatic and hedonic qualities.

As test participants, twelve persons were recruited of which three are female and nine are male. The age of the test users ranges from 23 to 45 with an average of 27. To test the system’s usability regarding the related activities, the subjects were assigned four basic tasks which reflect the anticipated use cases for the application:

- Finding a specific friend in the list and compare the performance by level,
• finding out for which equipment flexibilities are already defined
• creating a new flexibility and
• dealing with late negotiations.

To introduce the system to the participants, a short explanation on the application’s purpose and use context was given before the test. During the test, subjects were asked to think aloud and were allowed to comment on the interface. As hardware platform, an Apple iPad 2 was utilized.

Most tasks were successfully handled by all participants without further advice from the test moderator. The social comparison of a friend in the list was easily performed by all subjects. Merely three subjects stated they would like to compare more details on their friends additional to their level. In the second task, the identification of running, pending and historic flexibilities, two participants had initial problems in distinguishing running from pending equipment in the list while it was successfully handled by ten participants. The creation of a new flexibility was performed without crucial problems by all participants. The weather and day time information and the integrated chart on the amount of ESP to earn, however, were not directly recognized by multiple subjects. Nonetheless, the subjects were able to successfully submit their flexibilities, even without these additional displays. Also dealing with a late negotiation in the last task was performed without problems by all participants.

The usability test shows, that the prototypical user interface works well to create and manage demand flexibilities. Furthermore, it was found that a reliable submission of flexibilities was possible, even if the subjects did not make use of all supportive indicators in the creation screen. However, when discovered, the supportive displays were easily understood and provided additional information to the user. Also the surrounding functionalities, such as the social comparison and negotiation of flexibilities, were used by the subjects without problems. Overall, the test participants were able to use all provided features of the application without further explanations from the moderator. This points out the high level of the interface’s intuitive interaction design, which is especially needful for application which might only be used occasionally. The positive feedback from the usability test is assured by the results from the two questionnaires. The SUS scored with 84 out of 100 possible points, which can be considered as a result above average for a prototypical user interface and indicates a relatively high usability of the system. Also the AttrakDiff questionnaire shows very satisfying values regarding the system’s user experience. The average AttrakDiff scores (scale 0 to 6) lie at 5.0 for pragmatic quality, at 4.8 for the hedonic quality of identification, at 4.4 for the hedonic quality of stimulation, and at 5.3 for its overall attractiveness. These comparatively good results can be taken as indicator of a comparatively high potential of intrinsic motivation merely from using the system.

6. RELATED WORK

Although the area of gamification is quite new, it already is applied in numerous research, as well as commercial projects. A prominent example of gamification is represented by the location based social network foursquare. When ‘checking in’ in locations, such as bars or restaurants, users are rewarded with badges that essentially reflect the frequency of their visits. Also in the context of energy efficiency, several studies utilized game mechanics and social comparison to engage users in an active energy conservation [5, 11, 13]. In the EnergyWiz application [13], for instance, users are able to compare their consumption to the energy demand of other users. The system provides leaderboards, energy conservation challenges and a stylized status presentation to motivate users. However, none of these systems addresses the application of these techniques to encourage participation in demand response programs. Research on the motivation for a participation in demand response is mainly limited to the application of monetary incentives. While some studies take a closer look on consumer motives to engage in demand response programs [18, 8], the application of game mechanics was not yet investigated.

7. FUTURE WORK

In future work, mainly the following aspects should be addressed: the effort for the consumer to use flexible demand should be reduced as much as possible, the motivation for system use should be maximized and chances for an opportunistic use of the system have to be eliminated. To reduce the consumer’s effort in defining her consumption preferences, firstly definition and management of the flexibilities has to be ubiquitous. Additional to our proposed centralist submission approach, the consumer should also be able to define flexibilities coupled with the actual consumption or interaction itself that may lead to a subsequent energy demand. The possibility to define consumption preferences for a washing machine cycle, for instance, is best provided directly on the machine itself. Thus, the user does not have to perform actions additional to the original interaction with the consuming equipment, but finds the simple submission of flexibilities, such as a latest end point, tightly coupled to the actual adjustment of the appliance, which is required in any case. Nonetheless, a centralist system provides a global overview of all defined demand flexibilities and allows for remote definitions.

Another major requirement for the system is to incorporate further aspects of energy consumption or pro-environmental behavior in general. The emerging availability of domestic energy feedback devices already established a platform for home energy management. Thus, the acceptance of further applications in the same domain may be hampered. Additionally, an incorporation of the demand dispatch tool in a general energy conservation application would promote the possibilities of flexible demand also to end-users who initially intended to merely use the surrounding features. Also the reward system could be enhanced by introducing combined challenges or badges for flexible energy savings.

While the scoring system provides the means to reward a behavior that promotes the application of flexibilities on everyday electricity consumption, opportunistic behavior is not easily prevented. For instance, users might become encouraged in using their appliances more often than needed, simply to earn the desired points. A first step to prevent this behavior is the incorporation of the flexibility in the score as a separate factor, as proposed in our approach. Thus, the definition of many ‘short’ flexibilities is comparatively
worthless. Another technique to reduce the attractiveness of point hunting is the display of the respective energy costs or CO₂ emissions when running the appliance cycle. Displaying the reduction in CO₂ emissions by using flexible demand even promotes the application of flexibilities while informing the user that electricity is consumed. Furthermore the incorporation of the proposed point system into a more general game environment, as mentioned above, provides the possibilities to further prevent an increase of consumption due to opportunistic behavior. While the proposed point system might motivate to issue more consumption cycles than needed, simply out of the drive to gain more points, a surrounding reward system for the reduction of energy consumption provides the means to employ countermeasures to this issue.

To ultimately prove, or refine, the concept, further evaluation has to be carried out. Therefore, a long-term study has to be conducted, to provide insights on the benefits of choosing the proposed approach over monetary rewards.

8. CONCLUSION
In this work a user-centric demand dispatch system is presented, which focuses the encouragement of an intense and long-term consumer participation. To accomplish this, a motivational framework was introduced, including an optimized user experience, a game-like scoring system, social connection and pro-environmental aspects. This framework was implemented in a prototypical user interface for the submission and management of residential consumers' demand flexibilities. In a first user study, the system was evaluated regarding its usability and user experience. The results show that the user interface was found appealing and easy to use by all test participants and bears the potential of engaging the user in participation and thus to contribute to a better integration of renewables in modern electricity grids.

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10. REFERENCES