Peer-to-Peer Traded Energy: Prosumer and Consumer Focus Groups about a Self-consumption Community Scenario

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Abstract. Renewable energy cooperatives were found to facilitate the uptake of renewable and distributed energy resources and require the willingness of participants to trade energy within their local community. To gather user requirements for the design of such scenarios, we conducted two focus groups with potential participants. Prosumers (n = 7) and consumers (n = 9) worry about regulatory conditions and potential taxes applied on energy trading. We found that in particular consumers demanded for secure energy supply, while prosumers wanted to keep control of their energy production. Prosumers expressed their interest in detailed consumption and sales information, while consumers were interested in the legal matters of the contract and the energy source. Furthermore, the concept of connectedness was valued as the most important gamification approach for self-consumption communities, followed by the development of competence, in particular important for consumers.

Keywords: User-centered design · Smart Grid · Gamification · Blockchain

1 Introduction

The combustion of fossil resources accounts for two third of carbon emissions worldwide [3] and therefore progressively contribute to climate change [4]. In order to face ecological challenges, a changeover from the traditional, centralized power grid to an integration of renewable and distributed energy resources (DER) is needed [1]. DERs enable demand response, grid stabilization and reduce the transmission costs. Consequently, the integration of DERs applies for being more energy-efficient [2]. Different technical solutions are suggested to realize reliable trading of distributed produced energy, for instance the use of blockchain technology seems to be promising [6, 7].

Besides the technical design, user research can contribute to a usable implementation of solutions for locally produced energy and its trading. On a social level, renewable energy cooperatives were found to facilitate the uptake of DERs [5] in general. But the question remains: Which requirements need to be fulfilled to encourage people to participate in a local energy community in short- and long-term? Therefore, we conducted two focus groups with pro- and consumers.

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2 Related Work

2.1 User Research for Smart Grids

The involvement of active con- and prosumers in terms of optimal production and consumption of energy provides many opportunities for new, smart energy models facilitating the integration of DERs. The willingness of people to participate is one main contributor to the adoption [8] and success [11] of these models, as the development and transition to energy communities based on renewables in Denmark [16], Austria [18] and Norway [17] already have shown. Hence, the integration of user requirements, preferences and barriers is of fundamental importance in the design process [8, 9]. One of our previous studies [10] showed that pro- and consumer differ in their acceptance of energy scenarios involving DERs. Especially with regard to a self-consumption community scenario, consumers criticized the complexity and the uncertainty of costs, whereas prosumers favored the innovativeness of a Peer-to-Peer approach.

A field trial in Austria – the HiT Housing Project [18, 19] – showed that users were disappointed especially about the benefit-cost ratio. Eight residential buildings (129 apartments) were equipped with a heating system consisting of a biogas-based unit, a heat pump, and an energy storage. Residents perceived their effort to adjust their behavior as high, but the financial benefit was rather low. With regard to informational demand, they mentioned an interest in what kind of energy source was used, in order to adjust their consumption to locally produced solar power [19]. A promising suggestion for a possible user interface indicating availability of green power was made by Schrammel et al. [20]. Research shows that the implementation of energy communities, which are enabled with local production and supply, need the integration of user-oriented and social approaches to start and continue the transition to DER integration.

2.2 Gamification for Motivating Active Participation

Most concepts, which promote sustainable energy behavior, incorporate people as individuals motivated by self-interest [11]. As local energy approaches of production and consumption involve small communities, group-based approaches addressing motivational aspects of participation are interesting as well. In the field of human-computer-interaction, there is one motivational design strategy covering a range of individual and community interests, called gamification. It is defined as *"the use of video game elements, to improve user experience and user engagement"* [21]. Gamification uses elements that target the basic pillars of intrinsic human motivation. Namely autonomy, competency and relatedness. Within our two focus groups, we want to identify if and what kind of gamification strategy would be suitable for a user interface in a local energy community. The focus groups aimed at contributing to the user-centered design of a self-consumption community scenario. Therefore, we investigated *which requirements do pro- and consumers have for a self-consumption community scenario in terms of energy?*

3 Method

We decided to conduct two separate focus groups, one for pro- and one for consumers as a homogenous group composition is known to facilitate a common basis in the discussion [12]. A focus group is a qualitative survey instrument [12] and a moderated process in which a small group of 6 to 9 users [13] is stimulated to discuss a specific topic [12]. This informal technique helps to assess users' needs and feelings [13].

3.1 Sample

The consumer focus group was conducted with 9 consumers (4 female), who were on average 50 years old (M = 50.33; SD = 16.60). The majority (5) indicated to have a university degree as their highest level of education, followed by a PhD (2). In the mean (Mdn = 5.00) they lived in a city with "*100.000 to 500.000*" inhabitants. We had 7 participants in the prosumer focus group (one female) with a mean age of M = 48.00 years (SD = 12.22). Again, the majority held a university degree (6), here followed by one participant, who indicated an apprenticeship. On average also the prosumers' place of residence has "*100.000 to 500.000*" (Mdn = 5.00) inhabitants. The consumers "slightly" and prosumers "largely" agreed being affine to technology ($Mcon$ = 4.29; $SDcon$ = 0.49; $Mpro$ = 4.65; $SDpro$ = 0.73), least lies above the standard value [14].

3.2 Procedure and Materials

The focus group notifications were sent out via email to the participant panel of our research group. The two groups of interest were described as follows: 1. Prosumers: "*people, who produce electricity themselves, e.g. with a photovoltaic plant*"; 2. Consumers: "*people, who purchase electricity"*. The final invitation included an introduction to the topic and a description of the self-consumption scenario (Annex 1). First of all, the participants were asked to sign the consent form and a demographic questionnaire was handed (including age, gender, level of education, size of the city or place of residence, affinity for technology interaction [14]). Additionally, prosumers were asked to indicate the age and a description of their energy plant. Participants then received a briefing on the *NEMoGrid* research project [15] and the scenario. We then questioned openly about the potential advantages and disadvantages of the scenario and the desired information of the pro- and consumers in such a scenario. Keywords from the participants' statements were noted and placed on a table. Afterward, participants rated the importance of the collected information individually (Fig. 1). Therefore, they had to allocate max. 9 colored dots (red = "*I personally do not need this information.*", yellow = "*That's good to know, but I'm sure I just check it every once in a while.*", green = "*Very important, I always want to have quick access to this information.*").

Subsequently, we focused on the development of gamification concepts. Therefore, the pro- and consumers should complement three different sentences individually: 1. "*In order to strengthen my **competence** in dealing with energy, I would like, within the framework of my self-consumption energy community, that…"*; 2. "*To strengthen my*

Fig. 1. Focus group participants during assessment of information needs.

sense of ***autonomy*** *within my self-consumption energy community, I would…*"; and 3. "*In order to strengthen my sense of* ***connection*** *with other energy producers and consumers in my self-consumption community, I would…"*. Eventually, participants briefly presented their best idea to the group. Every participant received a remuneration of 50 € (approx. 55 $). The maximum duration was 2 hours.

3.3 Data Collection and Analysis

Qualitative Data. One research assistant took notes to document the group discussions. Additionally, we used a dictaphone to gather original quotations. We classified notes into positive feedback and concerns. For the qualitative data collected on an individual level (completions of phrases on gamification strategies), the written answers of each participant were split up into single statements. In a first step, the assignment to the available gamification approaches was reviewed. After that, a category system was built bottom-up. Descriptive frequencies per approach and category are reported to indicate major tendencies.

Quantitative Data. Firstly, we summated the number of dots indicating the importance of information needs and determined a weighted value per information requirement. Therefore, we took the colors of the dots into account (3 for one green dot, 2 for yellow, 1 for red). Secondly, we relativized this weighted value per information to the weighted total value of all requirements mentioned. Third, we generated a ranking of the requirements named in each focus group.

4 Results

4.1 Scenario Evaluation

Consumer Concerns and Positive Feedback. The warm-up discussion revolved mainly around ensuring the security of supply and the regulatory framework. The participants doubted storage capacities and volatile energy sources to be sufficient for a continuous supply. Consumers rated the applicability of this scenario as more likely to be in rural areas, due to the installation of space-consuming infrastructure. In their opinion, the high taxes on energy would certainly be passed on to the energy community. Participants in the scenario were expected to face bureaucratic hurdles for trading electricity. Furthermore, costs and effort were addressed critically. Some consumers feared that people with less affinity for technology would be excluded. In addition, they worried about the time required and had doubts as to whether the scenario is more cost-effective because new costs will emerge, e.g. for the algorithm, infrastructure, and maintenance.
On the positive side, the consumers stated that the scenario is innovative and can be combined with new technologies such as electric vehicles. Furthermore, one participant mentioned the environmental benefits. But one participant replied that the integrated blockchain technology is very energy-intensive and should be taken into account.

Prosumer Concerns and Positive Feedback. The main topics of the discussion were the installation costs and again expected regulatory difficulties. The prosumers considered the concept, it's infrastructure and administration as too demanding for communities of smaller producers and consumers. They additionally mentioned bureaucratic difficulties, with regard to the billing in apartment buildings and the separation of the own consumption. They worried about intensive maintenance costs that possibly would exceed profits. The principle of independence of the community was evaluated as a positive aspect by the prosumers.

4.2 Information Needs in a Self-consumption Community

Consumers Information Needs and its Importance. The consumers mentioned nine different aspects they would like to be informed about: 1. Security of supply (relativized weighted importance: 15.65); 2. Exit/Termination option (14.97); 3. Drafting of contracts (14.92); 4. Assessment of producers (11.56); 5. Power source (11.56); 6. Installation effort (10.88); 7. Definition of locality (8.84); 8. Information about grid stability (6.12); 9. Electricity mix (6.12). Table 1 illustrates the three most important needs with an exemplary quotation from both focus groups.

Prosumer Information Needs and its Importance. We gathered 14 different information needs: 1. Priority for self-consumption (13.04); 2. Consumer related information (12.07); 3. Definition of thresholds (10.43); 4. Power composition (7.83); 5. Taxation (6.96); 6. Temporal consumption information (6.96); 7. Sales overview (6.96); 8. Variable prices (6.96); 9. Price information (6.96), 10. Information about grid stability (6.09); 11. Data protection (5.22); 12. Comparative prices (4.35); 13. Weather forecast (3.48); 14. Sunshine duration (1.74).

4.3 Gamification and Motivating Extensions

Consumer Individual Ideas. Most of the overall 22 consumer statements (9) can be assigned to the approach *connectedness with others*, followed by the *competence* (8) and at least to the *autonomy* (5) approach. We formed categories for ideas mentioned more than once. The connectedness approach subsumed ideas on "*physical community activities*" (mentioned 4 times) and "*enabling exchange with others*" (2). The competence approach triggered the ideas "*offering topic-related learning*" (3); "*making expert knowledge accessible*" (2) and "*recommendations for behavior*" (2). Under the autonomy approach only "*ensuring security of supply*" (3) was mentioned more than once.

Creating or maintaining a sense of community was considered the central core of the concept. This could be achieved, for example, by information that creates a positive image of the community. At the same time, the formation of a community and the organization of coordination processes, e.g. with joint investments, was seen as the biggest hurdle. In the discussion on competence-promoting measures, the participants underlined a need for accessible, empirical knowledge. In addition, action-relevant information (times for favorable electricity prices) was desired. Autonomy related objections were mentioned as a kind of counter-argument to ideas on the topic of connectedness and had been discussed less in the group.

Prosumer Individual Ideas. The overall 21 individually written statements equally (7) distributed along the three gamification approaches. The built categories for connectedness again entailed "*physical community activities*" (3). Additionally, prosumers considered "*formulating common objectives*" (2) as interesting. The competence approach subsumed ideas dealing with "*making electricity information accessible*" (3) and "*making expert knowledge accessible*" (2). For autonomy, we formed two categories: "*reduce bureaucratic hurdles*" (2) and "*create individual control/influence possibilities*" (2). Example quotes for the most frequently named categories are illustrated in Table 2.

Table 1. Three most important information needs, illustrated by an example quotation and its relativized weighted importance (RWI).

Information need	Example quotation	RWI
Consumer		
Security of supply	"*My question is about the security of supply. How does this relatively small system guarantees that nothing can happen? Neither what can happen because our storage is empty, nor that the person who sells says: 'Well, I'm not selling at these prices today. I will wait half a year.*"	15.65
Exit/Termination option	"*If I have to make investments at the beginning, for example, another meter or something else. What options do I then have for getting out of the investment?* [...] *if I participate* [...] *and it does not correspond with my ideas, I would like to have the possibility to get out of such a concept and without great effort.*"	14.97

(*continued*)

Table 1. (*continued*)

Information need	Example quotation	RWI
Drafting of contracts	"*Let's put it this way: For me it shouldn't be any different from the current provider situation… that at the end of the year I see what I have to pay and in the best case that's cheaper than what I pay now.*"	14.29
Prosumer		
Priority for self-consumption	"*How much I sell and when; I'd like to be able to influence that by myself. Not that I would then sell more than I consume and then have to buy electricity. That should be realized in a way that I don't have to do anything.*"	13.04
Consumer related information	"*I lie in my hospital bed and I see when my wife turns on the dishwasher. That's interesting.*"	12.17
Definition of thresholds	"*I'd like to be able to set the thresholds* [from the automated selling system] *myself.*"	10.43

Table 2. Exemplary quotations for the categories formed from the sentence completions of the three gamification approaches.

Approach	Category	Example quotation
Consumer		
Connectedness	Physical community activities	"[…] *we meet at least one time per month.*"
Competence	Topic related learning	"*All participants are trained that all have the same level of knowledge.*"
Autonomy	Security of supply	"*Attach importance to functioning delivery!*"
Prosumer		
Connectedness	Physical community activities	"*Meet with the others.*"
Competence	Accessible electricity information	"[...] *clearly show what's happening. Production, withdrawals, various producers displayed, various consumers and their consumption behavior in the community; also external reference and its parameters.*"
Autonomy	Create individual control/influence possibilities	"*Interactive intervention options with regard to the variables.*"

In the subsequent discussion, ideas on the topic of connectedness were in the foreground. Here, social activities that reduce anonymity in the community were mentioned. The participants considered it as interesting getting to know the other consumers and producers personally and promoting the exchange among them. During the discussion, it was emphasized that fairness within the community should be ensured.

During the discussion of autonomy-based approaches, the participants emphasized that they highly appreciate the self-determination of energy supply. Competence-based approaches had hardly been discussed.

5 Conclusion and Discussion

Initially, the discussions in both focus groups naturally concentrated on hurdles, especially with regard to the functional and organizational implementation of a self-consumption community. Positive feedback was on a more general level. These results are in line with our previous research [10]. Here the innovativeness of the community-based approach was appreciated in contrast to the suspected increased effort and the diminished security of supply. The least concerns were especially mentioned from the consumers, as they are more depending on a secure supply. Indicated information needs underlined consumers' interest in the basic security of supply. Consequently, confidence-building information about producers in their community are considered important.

Furthermore, we conclude that local, community-based energy supply should be offered to consumers as an additional (and not exclusive) option to the "normal" grid-based supply. Accordingly, prosumers mentioned interest in functionalities that ensure control. This underlines their avoidance of the feeling of being overruled [10]. As prosumers showed a strong interest in detailed consumption and sales information, we recommend implementing user interfaces that entail information and control options.

Gamification approaches that promote connectedness with other community members have been considered as central by pro- and consumers. Social activities have been discussed in particular. Jans, Boumann and Fielding [11] underlined in this context already the importance of social identity theory. It promotes that interactions contribute to group forming and the definition of group identity. Further, the emphasis on similarities and differences to other groups will foster group definition. In addition, our results revealed that for consumers, building competence, e.g. by access to expert knowledge, is demanded. Therefore, we conclude that a combination of: 1.) Information about community members enabling to identify similarities and 2.) Possibilities to exchange competence, knowledge and therefore form a group identity can contribute to the motivation to share energy within a self-consumption community.

Our results contribute to requirements collection from the pro- and consumer perspective so that future work could build interface design for local energy communities upon it. Furthermore, future work can enhance requirements forming by the aggregation of individual and/or quantitative research.

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Annex 1: Description of the Self-consumption Community Scenario for the Pro- and Consumer Group

Imagine…

… You draw your electricity mainly from your local grid/your own photovoltaic (PV) system at home and you form a self-consumption energy community together with your neighbors. The energy supplier and distribution system operator considers this community to be a single entity. Within the community, you can trade energy with your neighbors at prices that are cheaper than those of the energy supplier. You have paid for the PV system installed in your household and the grid connection. In addition, a smart meter is installed in your home and you are connected to a storage facility that is also used by other people from the neighborhood. Furthermore, there is a storage facility that is used by you and your neighbors. Users can rent the storage from the energy supplier and charge it with the energy surplus from their PV system.

The essential part of this scenario is the trade of your surplus energy with your neighbors. Trading is automated by an algorithm that is realized via a double auction mechanism. This means by buying energy, the buyer is making an offer for the energy that a prosumer wants to sell. At the same time, the seller/prosumer also makes an offer for the price at which he wants to sell his energy. This means by selling energy, you submit your desired price for the energy as a prosumer, while the buyer makes a bid simultaneously. Trading is carried out using blockchain technology. A blockchain is a distributed database that manages an ever-growing list of transactions. The database is expanded chronologically linear, similar to a chain. In the end, new elements are constantly added (hence the term “block chain” = “blockchain”). When one block is complete, the next one is created. Each block contains a checksum of the previous block. Energy prices in your community (at the local market) are lower than real-time prices in the grid. However, you can still get energy from the grid. The price you get for the PV surplus you produce in your community is higher than the real-time prices in the grid and the feed-in tariff. Furthermore, the additional PV price is more attractive than self-consumption. The difference between the selling price and the levelized cost of electricity (LCOE) is your revenue. The LCOE is the average minimum cost at which your electricity must be sold to reach the breakeven threshold.

Costs for the construction and operation of a power plant during an assumed financial cycle of life and use. The energy supplier takes care of the P2P market’s management. There is a monthly invoice consisting of five components: You pay…

1. … the share for the use of network services (transmission and distribution of electricity). However, there is a discounted rate for your share of use.
2. … the price you offered in the auctions for the electricity you used. The money you pay is lower than a real-time price for electricity from the grid./… the amount of electricity you have drawn.

   - If you use your own PV generated electricity, you pay a levelized cost of electricity (LCOE).

- If you trade the PV surplus, the earnings depend on the auction. However, the money you receive is higher than a feed-in tariff or the real-time price of electricity on the grid.

Costs for transmission and distribution of P2P trading electricity are excluded. You can draw energy from the grid at any time, which is more expensive.

3. … the power storage facility. This storage battery can either be rented or purchased. Monthly rental rates or one-off purchase costs, therefore, do incur.
4. … the algorithm that fixes local (energy) bottlenecks and offers the ability to obtain cheap energy via auctions.
5. … the share for the P2P management carried out and set up by the energy supplier and distribution system operator.

By trading (locally) in your community, the energy transmission fees are lower. Although there are costs for the P2P (management) algorithm, these costs are less than the total profits. The advantage for consumers/prosumers are that, as a flexible consumer, he or she can obtain energy from a prosumer at a lower price than the network price/they sell their surplus energy to a flexible consumer at a higher price compared to the distribution system operator. You can reduce the payback time of your PV system and thus lower the levelized cost of electricity (LCOE).

In short, you pay your energy bill, including additional shares for storage and the algorithm.

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