Participation in Energy Transition - Challenges within the Scope of Smart Grids

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ABSTRACT

The inclusion and empowerment of civil society and economy are considered necessary prerequisites for the energy transition that has to be achieved. This contribution shows the process of participation approaches in general as well as a use case within the scope of smart grids in particular. The objective of this use case was to determine the users' willingness to participate in the respective project. A participation workshop was conducted using qualitative and quantitative methods. Results show that since the participants were informed about the system solution for the first time, concern about cost and security were corollary. We conclude that the workshop served rather as instrument to inform and enlighten private end-users providing a baseline to compare results of further investigations. The forthcoming challenge is to ensure an ongoing participation process to raise acceptance and willingness to participate.

KEYWORDS

Participation, hybrid grid, energy transition, smart grid, end-user acceptance, intention to use

INTRODUCTION

In order to counteract a constant global warming, social and economic transformations are required in addition to technical developments. Social innovations have recently become particularly important. These aim at a new social practice as well as at improved social living conditions. Transformations appear, for example, in terms of behavioural changes, new forms of organization, new decision-making and participation processes. The inclusion of civil society and economy are considered necessary prerequisites for the energy transition that has to be achieved.

Over the past two decades participation procedures experience social significance. The research about participation at sociotechnical transformation processes like the climate change has become an independent research field [1]. The diversification of society and the different existing groups within increasingly demand the consideration of their ideas and needs [2]. If affected target groups get the chance to be involved in planning procedures and to share their experiences, perspectives and ideas immediately, recent studies show that win-win solutions will be achieved [3].

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Participation refers to actors at the supply and demand side of the energy system. So it defines the empowerment and involvement of stakeholders and groups of players at a target project or enterprise. The general aim of direct involvement is to achieve mutual understanding of each perspective and to facilitate the transparency of (public) decision-makings through communication at eye level [4]. Further aims could be to merely inform stakeholders, to explore and consider stakeholders' opinions and feedback and also to induce active engagement. The latter includes the concepts of co-determination (i.e., affected and interested parties have the opportunity to codetermine at the development and implementation of a project) and self-organization (i.e., target groups develop and implement their ideas and measures to achieve changes or special goals) [5, 6]. These mentioned opportunities of participation need to be understood as a stair structure. The higher level contains the previous one. However, only the levels of co-determination and self-organization include active engagement. The last one represents a bottom-up approach. Bottom-up is defined as a process of 'politics from below' that is developed from the initiatives of civil society and private economy [7].

The current literature describes three partly interdependent ways in which citizens can participate in the energy transition: (a) as consumers, (b) as producers or investors and (c) as political actors or planners. (a) Involvement as a consumer can be achieved through energy-saving behaviour with electricity and heat, adapting behaviour for load balancing and mutual sensitization, for example through active participation in climate protection initiatives. (b) Participation as a producer or investor can be achieved through the purchase of energy-efficient appliances, the implementation of energy efficiency measures and financial participation in renewable energy projects. (c) Participation as a political actor or planner may be formal or informal through community council activities, citizens' initiatives and other engagement [8].

Participation of end-users has a positive impact on technology system success and relates positively to system service quality and customer satisfaction. However, system success depends on many different factors and surrounding conditions (e.g., type and size of the project, participation method, system development approach). Therefore human-centred design is crucial, especially for innovations in the field of energy systems. For this reason, responsive and deliberative forms of participation are called for [9] and have to be considered early in a system design phase and employed continuously throughout the project [10, 11].

The energy system, in particular the electricity system, is subjected to a sustained transformation due to the increase of volatile renewable energy resources. In order to continue a technically and economically efficient and secure network operation, it is assumed that additional flexibility in the electricity system will be necessary in the future. For example a flexibility demand of 17 TWh until 2030 is identified for Austria [12]. Not only energy providers take advantages out of the use of flexibility, also private end-users that are able to produce electricity themselves do. The investment in a photovoltaic system yields to perceived autonomy as well as to reduced ongoing cost.

PROBLEM STATEMENT

Private end-users have a huge range of different flexible applicable loads. On the one hand, the flexibility behind these loads may be achieved by behavioural changes in energy consumption, for example when using washing machines. Furthermore, devices like fridges or boilers could be connected with energy storages. Such flexibility may only lead to theoretical potentials for a real supply of flexibility because private end-users often will simply not react to external recommendations. On the other hand, devices that possess energy storages have the highest potential for a real supply of flexibility. For private households, this is the case for hot water (boiler/buffer storage) and space heating (thermal mass/buffer storage) because both cases provide comparatively high amounts of storage mass that is widely spread in various

households. Such flexibility allow a time-variable application of heat generation. The generation of hot water by electricity is also known as integrated energy. Thereby it is possible to transfer the thermal flexibility into the electricity sector and use it by means of specific regulatory strategies [13] like simulation-based models [14].
We illustrate a use case consisting in the development and demonstration of a smart grid using new business models in the small urban region of Hartberg, Styria, Austria. The general objective is to activate flexibility in the system. For this reason, the participation of private end-users is a key factor for demonstrating this concept. To provide a user-friendly framework, a multidimensional approach for flexibility use is chosen. Within this approach, comfort boundaries (like sufficient hot water, comfortable room temperature) have to be met, auxiliary power (rise the consumption of auxiliaries to minimize electricity cost) has to be optimized and electric heat generators have to applied at economically advantageous times. This approach operates automatically without the user's perception, nevertheless there is still an opportunity to deactivate the external regulation if needed [15].
In principle, each participation process also carries potential for conflict, which can be effective in every phase of the process (before/during/after) for different reasons [16]. For example, participation processes may fail if relevant stakeholders have no interest to participate, if there is a lack of possibilities to act or if social inequalities or different approaches cannot be compensated [17]. The objective challenge consists of achieving acceptance of private end-users and motivating them to participate in the project. Active participation of end-users is given, if they intend to use the introduced system solution. Thus, we identify the following **research question**: *Which factors affect the private end-users' intention to use the objective system solution?*

METHODOLOGY

General participation process

As soon as the project goals are defined, each participation process includes the identification of relevant stakeholders and the relevant participation activities to achieve the goals. Since there are different stakeholders, questions of interest are varying. Therefore, each activity requires an appropriate design to ensure a purposive implementation of actions. A standardized participation process is given in figure 1.

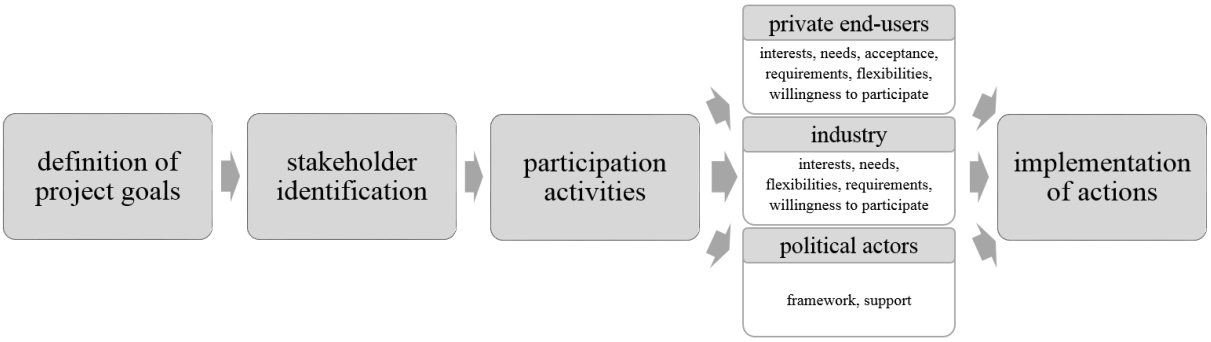


Figure 1. Standardized participation process

As objective use case, we present a participation workshop that took place in Hartberg. The aim of this workshop was to determine the users' intention to use the introduced system solution. Special attention was drawn to determine the requirements in terms of the technological solution which are intended to be used for development of the business models.

Procedure and measures

In spite of extensive promotion activities, only 18 participants attended the workshop. Data from seven people were excluded because their residential building was not located within the according region. The final sample consisted of 82% male (M_{age} = 46.2, SD = 9.4). The workshop was moderated by a project staff. After providing general background information about the project and workshop procedure, a three-stage questionnaire procedure was conducted.

Attitude. At first, a questionnaire was distributed to receive unbiased information concerning personal attitudes with respect to technological innovations. We used three subscales *curiosity, openness* and *interest* based on twelve items of the Technology Usage Inventory (TUI) [18] on a scale of 1 (“do not agree”) to 4 (“agree”).

Discussion. After the first stage, detailed information about the project and user benefit was provided. Within the second stage, a World Café with two groups was conducted to discuss the received information and clear out scepticisms.

Acceptance. Within the third stage, the distributed questionnaire was continued. Participants were asked to point out acceptance for the introduced system solution. Acceptance was measured using four subscales (*utility, reliance, usability, accessibility*) out of 14 items of TUI on a scale of 1 (“do not agree”) to 4 (“agree”). Three to five items composed each subscale.

Requirements. In addition, we were interested in requirements in terms of the technological solution that are intended to be used to develop business models. Therefore, the questionnaire was complemented with specific items for system requirements on a scale of 1 (“not important”) to 4 (“very important”). Up to four items composed the seven subscales we used. Example items include “Continuous information about my current electricity consumption” and “Rapid reduction of costs using the system”.

Intention to use. Participants were asked about the intention to use the introduced system solution. Four items composed this scale. Example items include “I would purchase this product” and “I would use the introduced product”.

Finally, the workshop was closed providing a look-out for the next steps within the project.

Analysis

We analyzed the data with correlations and used exploratory path analysis to detect influences on the intention to use the system solution. We assumed that attitudes and demographic characteristics affect acceptance and requirements, while the latter themselves affect intention to use. The hypothesized model is shown in figure 2.

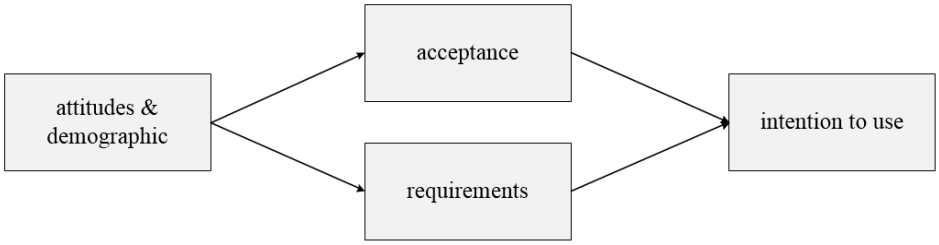


Figure 2. Hypothesized model

The path model consists of separate multiple linear regression models with standardized beta coefficients providing information about causal relationships. In addition, results of the discussion stage were documented and qualitatively interpreted using content analysis.

RESULTS

The descriptive analysis with respect to *attitude* showed that the internal consistency was unacceptable for *curiosity* ($\alpha = 0.41$) and for *openness* ($\alpha = 0.49$). Due to these results, these subscales were excluded from further analyses. The internal consistency for the subscale *interest* ($M = 3.34$, $SD = 0.45$, $\alpha = 0.78$) was satisfactory.

Regarding *acceptance*, the internal consistency of *utility* ($M = 2.33$, $SD = 0.61$, $\alpha = 0.70$), *reliance* ($M = 3.07$, $SD = 0.45$, $\alpha = 0.69$) and *usability* ($M = 3.14$, $SD = 0.48$, $\alpha = 0.71$) was satisfactory for each subscale, except *accessibility* ($\alpha = 0.54$). Therefore, accessibility was excluded from the analysis.

With respect to *requirements*, the internal consistency of *savings* ($M = 3.21$, $SD = 0.50$, $\alpha = 0.62$), *interaction* ($M = 2.73$, $SD = 0.56$, $\alpha = 0.60$), *information* ($M = 3.18$, $SD = 0.68$, $\alpha = 0.80$), *sustainability* ($M = 3.36$, $SD = 0.43$, $\alpha = 0.76$) and *faith* ($M = 3.50$, $SD = 0.74$, $\alpha = 0.63$) was at least passable for each subscale. The subscales *security* ($\alpha = 0.56$) and *efficiency* ($\alpha = 0.55$) had a poor internal consistency and were therefore excluded from the analysis.

The internal consistency for *intention to use* ($M = 2.93$, $SD = 0.65$, $\alpha = 0.83$) was satisfactory. *Intention to use* correlates negatively with *age* of participant ($r = -0.67$, $p < 0.05$), *reliance* ($r = 0.64$, $p < 0.05$) and *interaction* ($r = 0.74$, $p < 0.01$). Moreover, there are tendencies of positive correlations with *utility* ($r = 0.56$, $p < 0.10$) and *savings* ($r = 0.53$, $p < 0.10$).

Within acceptance, *utility* correlates significantly with *reliance* ($r = 0.82$, $p < 0.01$), the latter provides a positive relationship with *usability* ($r = 0.74$, $p < 0.01$). Within requirements, only the tendency of a negative relationship is provided by *savings* and *faith* ($r = -0.58$, $p < 0.10$).

Between acceptance and requirements, the subscales *usability* and *information* correlate positively ($r = 0.70$, $p < 0.05$). Moreover, *age* tends to correlate negatively with *savings* ($r = -0.58$, $p < 0.10$) and *interaction* ($r = -0.59$, $p < 0.10$). With increasing *age*, the importance of a *sustainable* solution increases ($r = 0.64$, $p < 0.05$).

Table 1 gives an overview of the descriptive analysis including correlations.

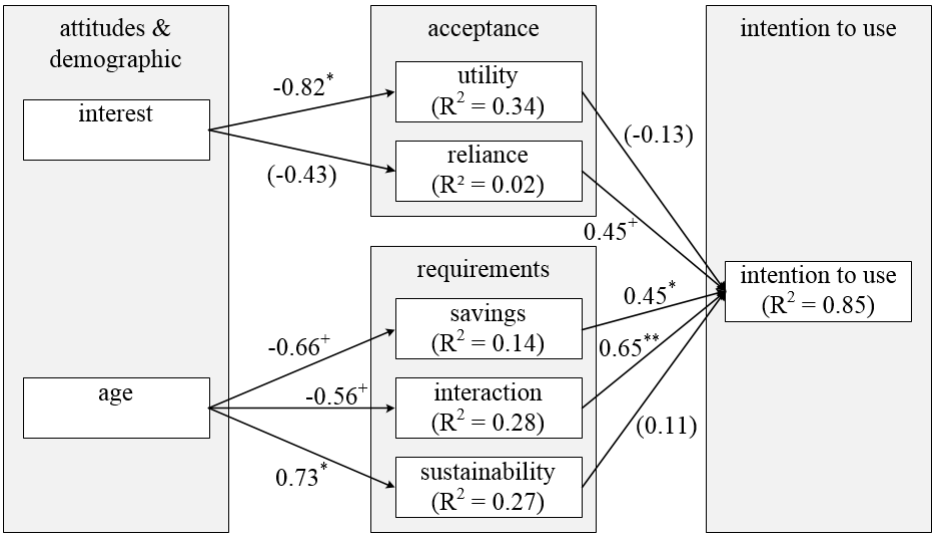
Table 1. Descriptive statistics and correlations

		M	SD	2	3	4	5	6	7	8	9	10	11
1	AGE	46.18	9.43	-0.16	-0.29	-0.36	-0.27	-0.58^{+}	-0.59^{+}	-0.46	0.64*	0.46	-0.67*
2	INR	3.34	0.45		-0.48	-0.31	-0.12	0.02	-0.19	0.04	0.07	-0.49	-0.30
3	UTL	2.33	0.61			0.82**	0.45	0.07	0.46	0.16	-0.08	0.37	0.56^{+}
4	REL	3.07	0.45				0.74**	0.23	0.30	0.51	-0.10	0.04	0.64*
5	USB	3.14	0.48					-0.10	0.17	0.70*	-0.18	-0.04	0.37
6	SAV	3.21	0.50						0.05	0.34	-0.39	-0.58^{+}	0.53^{+}
7	IAC	2.73	0.56							0.32	-0.07	0.12	0.74**
8	INF	3.18	0.68								-0.08	-0.35	0.59
9	SUS	3.36	0.43									0.16	-0.14
10	FTH	3.50	0.74										-0.23
11	ITU	2.93	0.65										

M = scale means, SD = standard deviations, correlations, $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, AGE = age, INR = interest, UTL = utility, REL = reliance, USB = usability, SAV = savings, IAC = interaction, INF = information, SUS = sustainability, FTH = faith, ITU = intention to use.

At first we tested for effects of demographic characteristics (*age*, *gender*) and attitudes on acceptance and requirements. While *gender* neither influences acceptance nor requirements,

results show that *interest* has a significant negative impact on acceptance regarding the system solution's *utility* ($\beta = -0.82$, $p < 0.05$). This result is contrary to the previous bivariate correlation analysis that did not indicate a possible relationship. *Reliance* and *usability* are neither affected significantly by attitudes nor by demographic characteristics.
In terms of requirements, *age* tends to influence *savings* ($\beta = -0.66$, $p < 0.10$) and *interaction* ($\beta = -0.56$, $p < 0.10$) negatively, while *sustainability* is positively affected ($\beta = 0.73$, $p < 0.05$). *Information* and *faith* are neither affected significantly by attitudes nor by demographic characteristics.
In addition, several issues were discussed in a World Café setting. It turned out that all scepticisms opened out into deepened requirements to consider. The most frequent issues can be categorized as cost ("the system should be more lucrative than photovoltaics and a heating cartridge", "there must not be any extra-cost"), sustainability ("predictions could additionally be provided to the system"), information ("provide reference values to compare my consumption") and security ("required to publish consumption behavior?", "data mustn't be handed over to third parties") in descending order.



+ p <0.10, * p <0.05, ** p <0.01, beta-values in brackets show nonsignificant effects.

Figure 3. Path analysis illustrating direct effects

Finally, effects of acceptance and requirements on *intention to use* were tested considering both the results of correlation analysis and the influenced dimensions of acceptance and requirements. The observed model has a comparatively low error since the variation of *intention to use* is explained to 85% by the subscales *utility*, *reliance*, *savings*, *interaction* and *sustainability*. Results show that the acceptance dimension *reliance* tends to influence *intention to use* ($\beta = 0.45$, $p < 0.10$), while *utility* has no significant effect on *intention to use* at all. Regarding requirements, *intention to use* is significantly affected by *savings* ($\beta = 0.45$, $p < 0.05$) and *interaction* ($\beta = 0.65$, $p < 0.01$). *Sustainability* has no significant effect on *intention to use*. The results of the path analysis are summarized in figure 3.

DISCUSSION

We conducted a participation workshop with the aim to determine the users' intention to use a system solution that activates the flexibility of private households. We found that the overall intention to use is rather high. In terms of acceptance, reliance has a significant impact on the intention to use the introduced system solution, whereas utility and usability have no effect. Only the system utility, which is a subjective indicator, depends on interest. As rather

unexpected, a higher interest in technology leads to less perceived utility. We assume that less technical-oriented persons notice a rather disproportionate system utility.

Within the subsequent discussion, a considerable degree of scepticism was identified. To that effect, the discussion results confirmed the first partial results of the path analysis since reliance is just an antonym of scepticism. Moreover, the participants were informed about the system solution for the first time, concern about cost and security are corollary. Nevertheless we gathered valuable information about considerable requirements that the solution must meet. The path analysis consequently shows that there are significant requirements to raise the intention to use. As expected, the system solution should provide savings to the private end-users. As rather unexpected, the more interaction options with the system are seen, the merrier private end-users intend to use the system solution. Both indicators depend on age, which was also expected. Especially younger participants attach more importance to savings and interaction options. However, especially type 1 errors may occur more likely due to the small sample size.

Nevertheless, we interpret cost and savings as central roles for participants that lead us to conclude that the participation workshop was not the proper instrument to *achieve acceptance* of private end-users. According to recent literature, the use of participation procedures to achieve acceptance if solutions are already established may lead to further challenges. Relevant parts of society are often also not included. Additionally, social and psychological interests and ideas can play a crucial role as well. In the first instance, private end-users often participate just in case if they are directly affected. They seem to participate more likely in simple questions than in terms of complex technical problems such as climate change and rareness of resources. [19].

To that effect, the participation workshop served rather as instrument to *inform* and *enlighten* private end-users about the system solution and gather information of considerable requirements and potentials. Moreover, the participation workshop provides a baseline to compare results of further investigations. To this end, the forthcoming challenge is to ensure an ongoing participation process to raise acceptance and intention to use. Above all, we have to select a well-considered method since it depends on characteristics of the target group, such as sample size, duration of the process and the desired level of participation [20, 21].

We got the first insights of the target groups and those facts that have impact of participation or non-participation of these groups. The causal relationship among age, interaction and the intention to use shows us potential for accessible target groups like Generation Y [22] or even afterborne generations that are rather young and technical-oriented, representing a huge amount of about 43% of the population in Styria [23]. We could promote participation of this target group by providing ongoing information about the development of the system solution and collecting feedback in terms of business models.

Collaterally, we have to reach other target groups by providing different types of information step by step. Since the importance of a sustainable solution increases with growing age, these information has to be focused on savings and sustainability. The approach’s advantageous framework that allows a minimization of electricity cost without exceeding of one’s own comfort boundaries has to be highlighted as benefit for private end-users.

However, participation activities need time and the willingness to be confronted with opposing positions. Discussions and tensions are possible and need to be considered. Participants often have different ideas and visions, but also different professional backgrounds and different experiences. But the exchange of different perspectives, needs and experiences can have a positive impact to enable better insights to different lifestyles, problems and perceptions of those people. It requires an analysed knowledge of the attitudes of all affected groups to create opportunities for "genuine" participation that eventually leads to a better and more comprehensive system solution.

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