Improving the Social Acceptability of Microgrids

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Abstract—The smart grid will have to occupy a prominent place in people's lives in the years to come, as the renewable energy mix desired by all governments implies a change of role from consumer to prosumer (contraction of the consumer to producer) of electricity. The adoption of micro smart grid technology, which links solar panels, batteries, and inverters to smart meters and power regulation algorithms, by a community (e.g., a residential sector), cannot be done automatically. This is what we studied in Switzerland, based on a qualitative survey (12 semi-structured interviews and 4 focus groups) to understand the psychological and social barriers, which prevent people from integrating such a technology. The results show that restraining forces are more important than driving forces and therefore that governments need to tackle the problem of social acceptance of smart grids before focusing on mainly technological aspects in their long-term energy and environmental policies.

Keywords—micro smart grid, qualitative survey, social acceptance, renewable energy, prosumer

I. INTRODUCTION

The micro-smart grid deployed in residential areas to ensure electrical autonomy based on the installation of solar panels on the roofs of buildings thus corresponds to one of the major strategies of the European Community. Indeed, the transition to a renewable energy mix requires strong citizen involvement to promote the stability of electricity networks. Until today, we are in an industrial logic of utilities that thanks to centralized production such as coal, oil, gas, hydro, and nuclear power plants of great capacity provide electricity in a relatively easy way to a large number of consumers.

In the case of micro smart grids, the consumer becomes a prosumer which is the contraction of producer and consumer. Consequently, it becomes necessary to develop scientific research to understand the obstacles and barriers that could affect the acceptance of these new digital smart grid technologies. Indeed, without the commitment of the user, a full-fledged actor of the smart grid community, the chances are minimal that such a project will succeed.

The whole aspect of regulation is done by intelligent algorithms. That's why we talk about smart grids. Rules of use and artificial intelligence will be programmed. The user will have his share of decision-making, in particular, thanks to devices that are called smart meters.

Therefore, smart meters will be needed to support electrical systems and microgrids as part of the energy transition. To predict and plan the output of local consumption and microgrids, they will need to collect data on other households in the community, in addition to monitoring the power cycles of appliances. These new smart meters, which we call Grid Edge Devices (GEDs), will require cooperative management. GEDs include virtually all the physical elements that are part of the micro smart grid such as solar panels, infrastructure equipment linking smart meters, inverters, energy batteries, appliances, and control systems.

In order to create context-aware and self-adaptive "energy" applications, such as tariff negotiation, energy transactions, and grid stability, GEDs are supported by state-of-the-art AI algorithms and cooperative distributed models. In essence, there is a need for all stakeholders (system integrators, independent software vendors, peripheral equipment vendors, and demand side owners …) to work together to develop a digital framework for a smart grid and renewable energy that works in a sustainable way.

In relation to the demand side owner and related social acceptance of the smart grid, it is necessary to be able to study in a prospective way the user experience (UX) of this "future prosumer", using qualitative methods (survey, immersion) to generate research hypotheses and then quantitative surveys to validate these research hypotheses.

An ethnographic survey is justified by the following point. In the context of smart grid and renewable energy applications, the behavior of the application itself depends on its context: country, regulation, social environment, climate, etc. Only in-depth interviews completed by immersions allow this context restitution and ensure that it is well taken into account in the implementation of the smart grid.

On the side of social sustainability, a study on the acceptance of the program will make it possible to accompany a communication campaign aiming at giving the end-users the means to consciously engage in the transition towards renewable energies.

This dimension of social acceptance is crucial for the development of a coherent and coordinated micro-smart grid in Europe. Indeed, the traditional B2C (business-to-consumer) economic model will be completely challenged in the coming years and replaced by C2C (consumer-to-consumer) economic models, since these consumers will also be producers. These new and very numerous players in the electrical networks are now called prosumers. This is where social acceptance comes in. It must enable these prosumers to comply with the rules of microgrid management and promote strong joint cooperation, without which this type of project is doomed to failure. The purely technical aspect of the project is therefore a necessary but not sufficient condition.

In the energy sector, consumer-oriented digital platforms are gaining momentum. It is crucial to consider the social factors that influence the acceptance of these systems by stakeholders. In the scientific literature, it is generally accepted that for a technology to be successfully implemented, its performance is evaluated according to the well-known Technology Acceptance Model (TAM). The development and dissemination of micro smart grids imply such a radical social change that we have to go beyond the TAM. We must thus identify all the social barriers that could compromise the implementation of our innovative energy platform. We need also to consider all dimensions of social acceptability: community, socio-political, and market.

“Social acceptability by design” must therefore be fully integrated into any project for the implementation of micro smart grids. Thus, as mentioned above, social acceptability is more than the acceptance of technology, it is about redefining the rules of exchange between actors whose social and economic role becomes more complex than in a traditional situation. Indeed, these actors become prosumers. This objective is achieved here through an ethnographical survey. On this basis of social acceptance, the design elements can be taken into account and will allow integration of an analysis of the physical and technical attributes of the electrical network from the early stages of the smart grid project.

This short paper is structured as follows. In Section 2, we provide a brief review of the literature related to the notion of social acceptance of smart microgrids. In section 3, we present the qualitative survey carried out to better understand the social barriers that may hinder the dissemination of smart microgrids. In Section 4, we present a synthesis of the fieldwork transcripts with an interpretation. In Section 5, we conclude and present what the next step of this research will be.

II. LITERATURE REVIEW

There is a great deal of academic work on the operation and implementation of smart microgrids. Fewer, however, deal with social acceptance. Most of these latter papers claim that the social acceptance of a smart grid is crucial to its success.

In the context of large-scale renewable energy technology projects, acceptance has been seen as a rather passive consent of the public. In contrast, household microgeneration of renewable energy requires active acceptance by homeowners. This microgrid situation, therefore, needs to be interpreted from a human factor’s perspective, focusing on individual behavior and social learning and identifying underlying requirements and user needs [1].

Indeed, a smart grid is not like the installation of an electrical appliance; it requires the acceptance of an entire community and more than that. A smart grid thus provides a service to a community. The service is defined in service science as an intangible production of which the customer is also a co-producer [2]. More recently, [3] showed that service co-creation is a “dialogical” process that involves a high level of partner participation and manifests in specific forms of co-creation.

Micro-smart grid management relies on a cluster of so-called prosumers, who are a contraction of producers and consumers, but who contribute to a given and defined power control system. This allows energy to be stored and exchanged between producers and consumers at a local level, with the complexity that the cluster or household is in turn both supplier and consumer (prosumer). For example, [4] showed that implementation is largely determined by issues of general social acceptance and argues that the success of a smart microgrid requires an 'upstream social construction', and as a consequence a lot of self-governance and flexible overall regulation that microgrids must enable.

However, according to [5], the decentralized socio-technical networks that underpin the electricity consumption of groups of consumers/end users need to be more autonomous in terms of self-regulation. They show that this notion of social construction and the upstream need to manage a social interaction between a group of prosumers through the 'smart meters' present in each household (with a prosumer role), as it is the visualization element that will enable this management within the residential community.

Through a systematic review of the literature, [6] explore the impact of moral values on the acceptance of smart grid technologies. The results show that moral values, which are often related to moral concerns such as privacy, justice, or trust, can be both drivers and barriers to smart grid acceptance.

Smart grid projects have a significant impact on electricity consumers by changing consumer behavior, culture, and processes [7]. Through a systematic analysis of the literature review based on 148 scientific articles, a taxonomy of socio-economic characteristics is proposed in terms of private (direct) costs, which are directly related to monetary costs paid by consumers, and social (indirect) costs, which consist of consumer perception, privacy, cybersecurity, and regulation. It is shown that social costs can hinder the deployment of smart grid technologies, even if these technologies appear to be useful based on private costs, while the scientific literature, unfortunately, focuses mainly on the latter.

The introduction of new smart grid technologies is necessarily a social and cultural transformation, involving adaptation to a new context co-created by the interaction between stakeholders and the people involved [8]. This study shows the importance of learning processes among stakeholders, especially the development of reflexivity among developers. Thus, the acceptance and adaptation to the implementation of a smart grid depend on the characteristics of each community.

Community participation is almost universally cited as critical to the sustainability of the microgrid system [9]. Community participation is most prevalent in the operation and maintenance phase, which these authors argue leads to positive social sustainability.

The sustainability of the smart grid energy-sharing process is highly dependent on consumer participation, making consumer participation and management schemes crucial in energy-sharing approaches [10].

There is also the notion of demand-side management associated with the smart grid, which is also crucial [11]. A social investment such as that required to be part of a residential smart grid community only makes sense if it is linked to demand-side management, where the prosumer also becomes a demand-side management actor.

Let's not forget that the smart grid is not only a way to achieve autonomy, but also to achieve sustainable development. Solar is a very volatile component of the energy mix and these smart microgrids are the real experimental element that will lead to a renewable energy mix in the future [12]. The coal/oil plant was actually quite simple from a production and management perspective. In line with many visions of the smart grid, consumers will play a greater role in their overall energy consumption, such as distributed renewable energy resources, electrical energy storage, demand response, and electric vehicles. Thus, the notion of social acceptance will be crucial for the future and at the level of civil society as a whole.

Finally, in terms of community governance, issues related to communication and management must be resolved before the full benefits of the smart grid can be realized [13]. In addition, smart grid design must consider how to maximize the use of grid resources and available power, ensure reliability and security, and provide self-healing capabilities. This again highlights the importance of our research in building social acceptance into the design from the outset. This is what we intend to do in future research by integrating these social acceptance requirements into the scenarios that will feed a digital twins approach [14] and thus develop coherent simulation scenarios (technical as well as social).

III. METHODOLOGY

When it comes to the acceptance of technological tools, much of the scientific research focuses on the TAM model (Technology Acceptance Model). This model argues that an individual's use of a new technology depends on two qualities, ease of use and the perceived usefulness of the new device. In our context, it is not only about the acceptance of technology in terms of usefulness. It is about redefining the rules of exchange between actors whose social and economic role is much more complex than in a classical situation. Therefore, we need to evaluate not only technological acceptance but also social acceptance, to remove the social barriers and give people a maximum chance to embrace this type of technology.

The TAM (Technology Acceptance Model) [15] was originally developed to assess the user acceptance of information technology. To answer the specific questions of social acceptance of technology, an extension of the TAM called UTAUT has also been developed (Unified Theory of Acceptance and Use of Technology) [16]. However, we believe that UTAUT is not adapted to the still not-known context of self-regulated smart grids.

We have thus conducted a qualitative survey based on semi-direct interviews as well as focus groups. The transcripts of the interviews have been then analyzed using the QDA Miner text analysis software. The aim is to identify the main social characteristics that enable the social acceptance of residential micro-smart grids. The chosen research strategy is based on the principles of ethnography [17]. Here, the aim is to describe and explain the social context of the respondents as they describe it. This is an appropriate strategy when seeking information about a “new” context in order to better understand and interpret it from the perspective of those involved.

We have conducted 12 semi-structured interviews with different profiles of Swiss smart grid stakeholders. We have also realized a series of 3 focus groups (involving microgrid experts with an economist, an engineer as well as a lawyer). This last part of the fieldwork aims to ensure that the social attributes derived from this research will be consistent with the more technical and logistical attributes of smart grids. All the interview transcripts have been coded, analyzed, and synthesized.

Specifically, the following profiles of respondents have been integrated into our purposeful sample: people who have solar panels on their own homes, have solar panels on a building they own, have wanted solar panels but had to give up installing them, live in an eco-district, work at a fuel cell company, companies that sell and install solar panels. For the interviewees who had no idea what a micro-smart grid was, we incorporated a hypothetical scenario vignette into our semi-structured interview [18], so that they can project themselves into such a context without having experienced it before.

IV. RESULTS

In this section, we present the results in ethnographic form, i.e. directly from our fieldwork. They are classified by theme, which is called a key. As the amount of information to be reported is very large, we summarize them in this short document in the form of a force analysis diagram (see Figure 1), which allows us to translate these results directly into restraining and driving forces and thus gives the reader a synthetic view of the results.

The main elements appreciated by our respondents are the cohesion of the group, the knowledge of each of the neighbors, regular meetings, mutual aid, diversity, absence of car noise, calm atmosphere, and awareness of environmental issues.

The main elements disliked by our respondents are the appropriation of common spaces by certain people, lack of privacy, and risk of living in autarky.

When applying the hypothetical scenario approach in our interviews, other elements are collected such as rules imagined for a community living on a microgrid: no waste of electricity, lazy attitudes not tolerated, coordination of schedules, favoring walking and biking, reducing the use of electric cars, electricity quotas, good division of tasks, especially regarding the maintenance of infrastructure, shared responsibility, well-defined goals (SMART) and means of monitoring their success, measurement of the community's environmental impacts (e.g., plastic waste). Interestingly, these respondents have a much more holistic view of themselves than those who are already familiar with smart microgrids, which is an interesting result that will be studied in our future research.

We also observe that trust elements are required by all respondents. This is the case for the technical salient attributes: energy-efficient buildings, assurance that infrastructure is working properly and regular monitoring, emergency contacts, a solution to store energy (so that they have reserves for the winter), and information sessions for newcomers. This is also the case for the mental salient attributes that require trust: team spirit, seeing that everyone is involved and making an effort, contingency plans before starting the project, ensuring that other community members are aware of the value of energy, being able to identify with the values of the project.

In the synthesis, we first summarized the recurring elements shared by most of the respondents. In the rest of this section, we present the atypical elements, i.e. those that concern only a few respondents. As such, among the respondents, several opinions were shared on different issues.

Firstly, with regard to price, six interviewees considered electricity to be closely linked to the economy. Four of them consider the profitability of installations to be a key issue, while three respondents think that the increase in electricity prices is an incentive to investigate having their own energy source, such as solar panels. Four respondents felt that installing solar panels was expensive and that external financial support was needed, and three felt that the high price was a barrier to buying solar panels.

Two respondents feel that environmental friendliness is not enough of an incentive to install solar panels, while four feel that environmental friendliness is a good motivation to take action in this direction. Two respondents believe that electricity and microgrids are related to the environment, while two believe that learning more about these issues has increased their awareness of environmental issues. In addition, two respondents believe that people have different views and values about better energy sources. In addition, two respondents felt that members of a community must have similar values and be committed to these values.

In terms of responsibilities, four respondents felt that in a community each member must take their responsibilities seriously. Two of them also think that the sense of responsibility is increased in a community where everyone is interdependent.

Regarding group cohesion, four respondents think that it is pleasant to have good group cohesion in a neighborhood. In addition, two of them think that it is very necessary for a community. Two respondents think that people need to be actively involved in order to build group cohesion and two others think that the influence on members of a group is stronger when there is group cohesion.

On the topic of monitoring and emergency plans, four people felt that regular monitoring and maintenance of infrastructure was necessary for people to feel safe. Two felt that access to information about their own consumption was important for other members of the microgrid. In addition, two respondents believe that risk and crisis management need to be put in place so that members can feel safe.

Living in a community means better relations between neighbors, according to two respondents. In addition, four respondents felt that community members need to make collective decisions rather than individual ones. Two respondents felt that for a community to function well, members need to see others actively involved, while two respondents felt that members of a community who are not motivated to get involved should not penalize the progress of others.

In terms of knowledge and information, four respondents felt that being involved in the process of installing solar panels had taught them a lot about the issue, even though the process was not successful. Several opinions on these topics were shared by two respondents, not the same two people each time; information on how to get involved in the process of installing solar panels can be hard to find; knowing that everything is under control is essential to feel safe; communication is crucial in communities, as it is better to give too much information than too little; it can be difficult to know the amount of electricity you are using; and word of mouth has a strong influence on one's opinion of solar panels.

In terms of consumption habits, four participants think that having solar panels or being part of a microgrid means being more conscious of one's consumption. On the contrary, three felt that people do not seem to be very careful with the amount of energy they use and that they have wasteful habits. Two respondents felt that habits could easily be changed if the necessary infrastructure was in place.

Administrative procedures and laws are unclear and complex, according to three respondents. However, three others said that they had no problems with these procedures and that the process went smoothly. Two people felt that the procedures for installing solar panels in small areas were drastically different from those for large areas. In addition, two respondents felt that the administrative procedures should be simplified, standardized, and centralized, and two others felt that support from politicians and distribution network operators was needed to improve these procedures.

Three respondents believe that there may be trial and error and grey areas in the implementation of resource management. Three of them think that resource management should be applied not only on a small scale but also on a larger scale. Three others believe that a combination of technologies, for example, a mix of photovoltaic and thermal panels, is a good solution for better management. Two respondents felt that the proportion of available roof space to be covered by solar panels should be well thought out. In addition, two respondents felt that resource management should be organized and planned by the community rather than improvised. Two respondents felt that the role of distribution network operators in resource management was unclear.

Regarding consumption rules, two participants think that electricity quotas could be a solution to manage the electricity consumption of microgrid users. Another opinion, shared by two respondents, is that buildings should have low consumption to avoid wasting electricity. Two respondents believe that there should be a change in consumption habits so that conservation behavior becomes the norm.

With regard to autonomy, two respondents felt that total self-sufficiency entailed certain risks, such as not being able to leave one's home. On the contrary, for two other respondents, the idea of being self-sufficient is pleasant and motivating.

In summary, in Figure 1 we see that according to our assessment there are more restraining forces than driving forces, which shows that today, according to Kurt Lewin's change management theory, the risk of success of a smart microgrid is minimal. The only way to increase its probability of success is either to get rid of the restrictive forces or to include more driving forces. This diagnostic force analysis is qualitative. However, it is a good indicator, before disseminating microgrids in society, that work needs to be done on the social acceptance of microgrids.

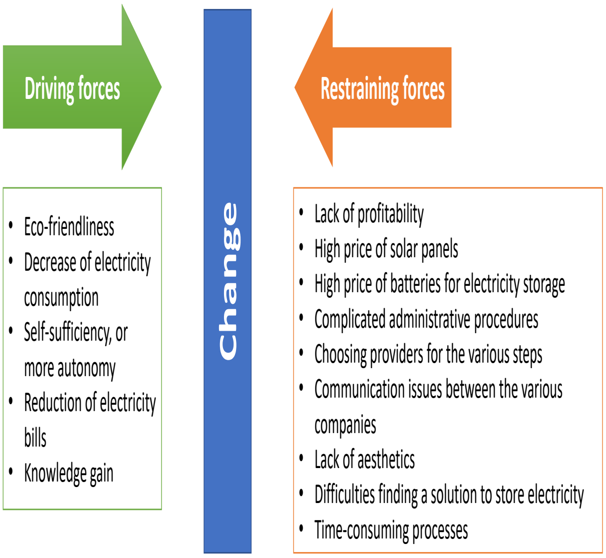

Fig. 1. Main results compilation incorporated in a force analysis diagram

V. CONCLUSION

In this paper, we present the main elements of the social acceptance of smart grids in Europe based on a qualitative survey, the aim of which is initially purely exploratory since very little is known on this subject. In a second step, based on these findings, we will carry out a quantitative survey in order to measure precisely the share of these social attitudes in order to counteract or compensate for them to facilitate the dissemination of micro-smart grids. We will also use them to feed a digital twins program in order to integrate a "social" scenario in addition to technological and technical constraints in order to best simulate the user experience in a smart grid context. Indeed, this research is part of a complete European project between Switzerland and Sweden (LASAGNE), which aims at making these autonomous electric systems socially sustainable and not only technological.

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