The Aggregator as a Trust Builder in a Renewable Energy System

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***Abstract*—This paper focuses on the role of the aggregator as a trust builder in a smart grid with consumers and prosumers. An aggregator plays a new role in the energy market and represents a group of consumers and prosumers toward the market. The aggregator can negotiate prices and trade flexibility for its consumers and prosumers. Trading flexibility is vital to shave peaks in energy consumption. A survey among early adopters of renewable energy in households revealed a lack of trust in transferring control of electric vehicle charging, heating, and household appliances to an aggregator. The paper proposes measures to improve trust in the energy market, focusing on the aggregator role. Three categories of measures are suggested: regulatory, technical, and organizational, combined with a plain language policy.**

Keywords-smart grid; flexibility; trust; prosumer; aggregator; ecosystem; plain language.

I. INTRODUCTION

A prosumer is both a producer and a consumer. In the electricity market, a prosumer produces electric energy from renewable sources, such as solar panels. Excess energy can be sold to the grid. An aggregator plays a new role in the energy market and represents a group of consumers and prosumers toward the market. The aggregator can negotiate prices and trade flexibility for its consumers and prosumers.

A recent survey by the authors among early adopters of smart home technologies and renewable energy production in households relieved a significant lack of trust in the energy market [1]. Trust has decreased even more as energy costs have soared throughout 2022. In Norway, the Facebook group demanding lower electricity prices has 620.000 members, and the media presents new stories about the consequences of soaring prices every day. Polls show that government support is at an all-time low, and commentators go a long way in pointing to the energy crisis as a reason for this lack of support. It seems that trust is at an all-time low, at least where energy is concerned, yet trust is perhaps the most critical factor for conducting effective transactions and making things happen smoothly. A low level of trust in government and institutions increases the risk of direct action by citizens [2]. It is even said that trust is the key to understanding the dynamics of social relations, to the extent that it is often viewed as the glue that holds society together [3].

The current energy crisis emphasizes the consequences of falling trust levels. The electricity market seems to be part of the problem since pricing mechanisms are complex and challenging to understand for the average citizen. For example, the algorithm "Euphemia" predicts future prices and is complicated and hard to explain. The whitepaper describing the algorithm's work is 53 pages long and very technical [4]. This complexity is likely part of why people distrust the energy market. When market experts talk to the media and try to explain why prices are high, explanations tend to vary between different factors, such as hydro basin water levels, the cost of natural gas or CO_2, and this leads to confused public thinking that the real reason simply is that "someone" wants prices to remain high.

Based on the above, it seems that communication, or rather a lack of clear communication, is part of the problem. We know from other fields, such as health, that plain and understandable communication is essential for trust [5].

In this paper, we propose three classes of measures: regulatory, technical, and organizational, combined with a plain language policy to alleviate the current situation and contribute to a higher level of trust in energy market institutions, which can aid the transition towards green energy. The measures are shown in Fig. 1.

Fig. 2 illustrates how traditional power grids transfer electricity from producers to consumers. The generated electricity by the power plants goes through the transmission network operated by the Transmission System Operator (TSO) and the regional network operated by the Distribution System Operator (DSO), then to the end user. The transfer is one-way; the end user must pay for electricity based on a tariff.

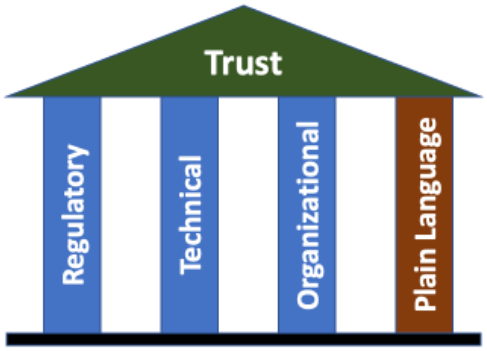

Figure 1. Measures to obtain trust

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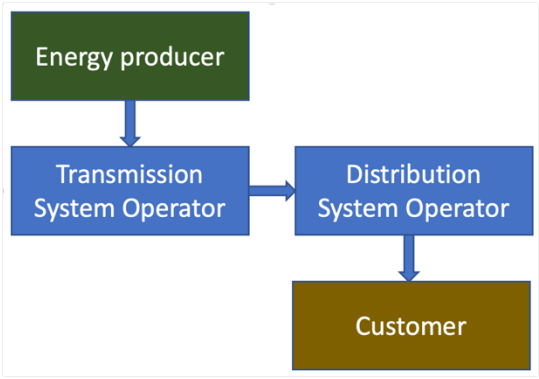

Figure 2. Traditional power grid.

With the development of renewable energy sources, consumers can produce electricity from solar panels, windmills, and geothermal power. This new role is often called prosumer. Smart grids enable a two-way energy transfer, allowing prosumers to produce and sell energy. A smart meter records the amount of energy transferred in the power ecosystem.

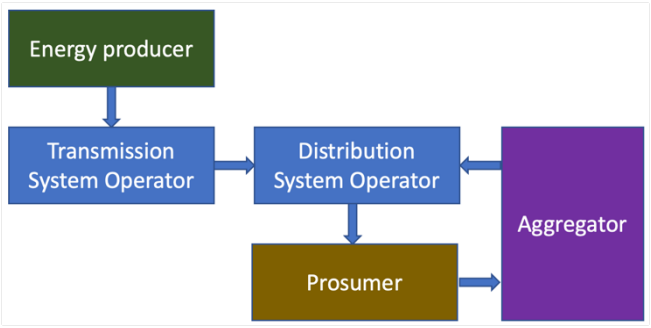

Figure 3. Power grid with prosumers and aggregators.

The aggregator is a separate entity representing several prosumers. An independent aggregator is defined in the EU Clean Energy Package (CEP) in Art. 2 (19) of the Directive (EU) 2019/944 [6] as "a market participant engaged in aggregation who is not affiliated to the customer's supplier." Aggregation is "a function performed by a natural or legal person who combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market." The traditional suppliers can provide aggregator services like demand response, but they haven't taken this responsibility since their main business is selling energy. Therefore, the role of independent aggregators has emerged [7][8].

The aggregator may negotiate terms with consumers and prosumers and handle transactions internally between consumers and prosumers. The aggregator may also provide electricity storage and offer electricity storage as a service to customers without storage capability. The aggregator plays an essential role in achieving flexibility. Grid flexibility refers to the ability of a power system to maintain a balance between generation and load during uncertainty, resulting in increased grid efficiency, resiliency, and the integration of variable renewables into the grid [9]. The gain from such flexibility is savings for the prosumer since electricity is cheaper in off-peak periods. Flexibility can postpone infrastructure upgrades and investments due to better grid utilization for the TSO and the DSO.

The authors were part of the ERA-NET+ Smart-MLA project [10] that designed and developed a cloud-based aggregator solution to optimize demand response and increase grid flexibility for renewable energy usage. Smart-MLA aimed to raise consumer and community awareness of demand response aggregating mechanisms. The project created user-friendly interfaces accessible through web pages and web services, allowing consumers to configure, control and monitor their appliances. Aggregators could also access these web services to securely analyze, plan, and forecast energy consumption and generation without the need for own infrastructure.

In the summer of 2021, the authors surveyed early adopters of home automation technology as part of the Smart-MLA project. The respondents were approached using Norwegian Facebook groups relevant to smart homes. The survey asked about demographic information, existing household installations, and the sentiments towards transferring control of electric vehicle charging, heating, and household appliances to an aggregator. The survey was open for five days and attracted 209 respondents. Fifty-two respondents used the opportunity to answer open-ended questions [1].

One clear result was a lack of trust in the energy market and its actors. Generally, the respondents expressed a low willingness to hand over control unless highly compensated. A large majority were positive about flexibility but wanted to remain in control.

One response was: "*Energy companies will never be allowed to control anything in my house. With their hidden terms and conditions, they have repeatedly shown that they can't be trusted.*"

Another was: *"The DSOs…have neglected to invest in the grid for the past 25 years while paying out hundreds of millions to shareholders. It's time they step up without shoving the [financial] burden onto consumers."*

And a third was: *"I don't trust them. What if something goes wrong?... and if the system is able to cut costs, that won't get back to consumers."*

These are three representative responses from the survey. There may be many reasons for the lack of trust, but the most important is a long-lasting competition with incomprehensible and incomparable terms.

The results from the survey were the inspiration to investigate possible ways for aggregators to build trust with consumers and prosumers.

The rest of the paper is organized as follows: Section II discusses flexibility and trust, followed by Section III, proposing measures for prosumers to trust an aggregator. Section IV concludes the paper.

II. FLEXIBILITY AND TRUST

The electricity demand varies throughout the day. The price of electricity follows the demand. Shifting some of the

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load to periods with less demand is advantageous for all parties. The consumers will reduce their electricity bills, while the grid operator can delay investments in new grid infrastructure.

Flexibility happens when consumers and prosumers offer to shift their loads. A single household will not contribute much, but if hundreds or thousands of consumers and prosumers provide flexibility, the impact will be high. The peaks will be shaved by shifting some load to periods with less demand.

A flexible consumer or prosumer can decide to postpone consumption of energy, e.g., for electric car charging or heating, until the total demand for energy becomes lower. The distribution system operator or an aggregator can handle flexibility. A typical example of flexibility is to render control of electric car charging, with the constraint that the car should be fully charged at 7 am in the morning.

Flexibility depends on trust. A consumer or prosumer must trust that the aggregator or distribution system operator fulfills their obligations, e.g., that the car is fully charged at 7 am. A consumer or prosumer that lacks trust will not transfer control to a not trustworthy entity.

In the energy market, the aggregators, prosumers, and other actors must deal with the complexity of interacting with organizations and thus face the necessity to reduce this complexity before participating. According to the complexity reduction mechanism suggested by Luhmann [11], familiarity and trust address essential aspects of the complexity within organizations. Familiarity and information sharing inside organizations and crossing the organizations are fundamental for building trust.

Piderit and Flowerday [12] observe two different views of trust: The first is based on confidence or risk in the predictability of the other party's actions, and in this instance, parties hedge themselves against uncertain events through guarantees, insurance, or law. The second view is based on confidence in the other party's goodwill, which relies on faith in the other party's integrity.

The first view relies on regulations, while the second relies on the parties' relationship.

During the work for the project SMART-MLA, the aggregators will plan and forecast the consumption and generation from the customers and prosumers (wind power, solar power) in a community. The aggregators and prosumers trust each other in the common concern for climate change, interest in new technologies, and environmental contribution. In contrast, the prosumers don't trust the aggregators for the issues of security of energy supply, immature technologies and business models, and expensive investments. The challenge is more prominent for renewable energy sources since photovoltaic and wind power must be produced instantly when sunshine or wind is present. The energy created from the sun and wind varies with weather conditions and is hence more challenging to integrate [13]. Therefore, strengthening the trust between the prosumers and the aggregators becomes a significant issue.

III. MEASURES TO CREATE TRUST

As we have demonstrated above, there is a strong link between grid flexibility and trust among aggregators, consumers, and prosumers. We propose to make efforts within the four categories below to build trust for the actors and reduce the risk of misbehavior: Regulatory measures, technical measures, and organizational transformations combined with a plain language policy.

A. Regulatory Frameworks

Without trusting others in the electric energy market, people would be confronted with the incomprehensible complexity of considering every possible eventuality of every person around before deciding what to do. Such complexity would be so overwhelming that, in many cases, people would refrain from acting. Trust is not the only complexity reduction method; rules are powerful techniques for reducing complexity. However, even when there are rules, trust is essential because there is no guarantee that other people will fully abide by them [14].

Therefore, regulatory measures are one of the pillars of building trust so that participants behave within a specific framework and non-compliance can be punished. Parliamentary acts, government regulations, and the energy sector, through self-regulation, may establish regulatory measures. Regulatory measures, such as EU and Norwegian national regulations, may instruct the market actors to comply with rules and regulations.

1) EU Energy Regulations

According to the EU Clean Energy Package (CEP), Member States shall enable demand response through independent aggregation. Directive (EU) 2019/944 Art. 17 contains the principles the national regulatory frameworks must respect [6]. Regulation (EU) 2019/943 Art. 59 1(e) states that a new network code can be developed in the area of demand response, including rules on aggregation, energy storage, and demand curtailment rules [15]. Network codes are typically used to harmonize the regulatory frameworks at the national level [16].

Under European frameworks, the energy participants have confidence in their clear expectations of what other actors will do, based on EU regulations and previous interactions.

The regulations reduce the need for extensive negotiations, detail resolution, tight transaction control, etc. These EU regulations aim at long-term orientation, then increase the acceptance of interdependence and create commitment among energy actors. Furthermore, trust built on the common EU energy frameworks also reduces risk and transaction costs since these frameworks are essential in almost every contractual agreement. Therefore, EU energy regulations enable trust among the participants as well as the quality of business relationships. Without EU energy regulations, the lack of trust creates control-oriented and defensive communication that degrades communication and then cuts off the energy transaction across the countries.

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2) Norwegian National Regulations

The Norwegian electrical energy market opened for competition when the Energy Act entered into force in 1991 [17]. The Norwegian Energy Regulatory Authority (NVE-RME) ensures the regulatory activities. NVE-RME has played an active role as an energy market regulator in developing network regulation besides EU regulations, real market access for all customers, simplified supplier switching procedures, securing security and quality of supply, and efficient regulation of the energy system operation in Norway. In 2018, NVE suggested a mandatory structure for the grid tariff to incentivize lower peak loads [18].

For the prosumers and other participants in the power market, official regulations can standardize contract terms, establish a common tariff structure, promote competition, and make it easier for customers to change electric power suppliers and connected services. According to the Norwegian official regulator NVE, all consumers have a right to produce and sell surplus electricity. The network companies are obliged to connect prosumers and receive their production. Prosumers feeding in less than 100 kW are not charged the fixed component for generation. Prosumers can choose their own electricity supplier that supplies their need for electricity and buy surplus electricity from the prosumer. In 2020 there were about 6 800 prosumers in Norway [19].

3) Self-regulation

The energy sector can take responsibility through self-regulation. In 2020, Renewables Norway [20] and Distriktsenergi established "Safe Energy Trading" to make the industry more transparent and customer friendly. The certification scheme allows energy companies to prove they follow best practices and commit themselves to improve customer relations. Self-regulation is a market-driven approach to tackle industry challenges and implement regulations by adjusting marketing and enhancing customer dialogue in line with requirements.

B. Technical Measures

Albinson, Balaji, and Chu [21] argue that technology can help build trust among stakeholders and create benefits for society. They suggest four pillars of trust, shown in Table I.

Their use of technology focuses on information handling. In the energy market context, two specific technologies may be particularly relevant: (1) Advanced Metering Systems (AMS) to give consumers and prosumers more insight into electricity use and production, and (2) Blockchain technology, sometimes referred to as Distributed Ledger Technology (DLT), which makes energy transactions unalterable and transparent through decentralization and cryptographic hashing.

1) Advanced Metering System (AMS)

For customers in the distribution grid, AMS with smart meters can offer the technology for new grid tariffs based on hourly metering consumption, which will incentivize the flexibility of consumers and prosumers.

TABLE I. FOUR PILLARS OF TRUST [21]

Transparency and accessibility
• Enabling customers to easily evaluate the company and its offerings. • Making business terms, such as additional fees, privacy policies, and terms of service readily accessible and easily understandable. • Clarifying how self-learning algorithms operate. • Providing line of sight into supply chains.
Ethics and responsibility
• Ironing out complaints in a sensitive and timely manner. • Stopping misinformation in its tracks. • Encouraging inclusion with tools that test fairness and detect biases. • Implementing safeguards to promote stakeholder welfare along with digital controls that prevent unethical or inappropriate use of technology.
Privacy and control
• Putting control of personal data in users' hands. • Improving accuracy of consumer data. • Being frugal with personally identifiable information.
Security and reliability
• Verifying the identity of people claiming to be customers or providers to reduce impersonation and fraud. • Using automation and AI to reduce errors and fraud. • Proactively alerting users in the event of suspicious account activity.

According to the Norwegian regulations, the smart meters should have standardized interfaces that allow for communication with external equipment; be able to connect different types of meters (e.g., gas, heat, water); secure data storage in cases of voltage outage; send and receive price information (from energy contracts and network tariffs) and signals for load control and earth fault detection [22].

The smart meters are designed to meter the power flow in both directions, to and from the customer, enabling customers to invest in renewable energy sources to become prosumers.

2) Blockchain Technology

Transparency and accountability are essential for building trust. A blockchain allows the actors to store transaction data in an immutable, distributed ledger. Smart contracts that can be executed on the blockchain can replace intermediaries in the transaction process [23].

The Smart-MLA project developed a blockchain-based solution for handling settlements between an aggregator and its prosumers [24]. A private blockchain was chosen since the costs of registering a transaction on the blockchain was many times higher than the actual amount of the transaction.

Smart contracts on the blockchain are self-executing when agreed conditions are met. It is possible to use smart contracts to set constraints on selling and buying prices.

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C. Organizational Transformations

Ahmad and Huvila studied the relationship between organizational change and information sharing. They found that if organizational changes are perceived positively, trust between employees and in management will increase, which consequently will enhance information sharing [25]. We believe that trust between prosumers and aggregators will also increase if the organizational changes are perceived positively. More information sharing means more transparency.

Trust can be seen as a cornerstone of work relationships and a key component of organizational effectiveness between the prosumers and aggregators. The "cooperative" model can be the organizational measure for the aggregator to build trust [26].

The International Cooperative Alliance (ICA) defines the term "cooperative" as "an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through jointly owned and democratically controlled enterprise" [27].

ICA has set out the collaboration principles: self-help, self-responsibility, democracy, equality, equity, and solidarity [27]. The company and the partner must also reflect four ethical values: honesty, openness, social responsibility, and caring for others. In addition, both parties need to be communication-based, multilevel, culturally rooted, and dynamic. In the smart grid ecosystem, the aggregators and prosumers must reflect these cooperative values when they want to build trust in each other [28]. Trust and sharing information will enhance each other's commitment and motivation to achieve grid flexibility.

D. Plain Language

Plain language initiatives emerged from the public sector's need to communicate better with citizens. Studies of public services found that many services and communications from the government were difficult for citizens to understand [29]. Language can be an instrument of inclusion but can also exclude, discriminate, and reinforce existing and unwanted power structures [30]. Plain language initiatives have sprung up to address this in several countries. Plain language is defined as "correct, clear and user-centered language in texts from government" [31]. It involves helping readers understand the text through the organization and structure, breaking up of complex information, simple language, and clear definitions of technical terms.

As there is a clear connection between language, understanding and trust [5], we argue that using plain language is essential for the other three measures to have an effect. There are several approaches to developing plain language, and a plain language strategy should probably involve several of these. One example is readability indexes, algorithms that measure the readability of texts through word recognition, string lengths, etc. [32]. In addition, those responsible for communication with customers' need training in plain language writing techniques, such as guidelines for structuring text, and which words to choose for a given audience.

There are several case studies on the effect of plain language, some of which are presented in [33], showing how different actors in the public sector have worked systematically and strategically to implement plain language in their communication with the outside world. These measures have led to fewer complaints and more satisfied service users simply because they understand the communication they receive. Given the confusion related to electricity pricing mentioned in the introduction, we argue that a plain language strategy from the actors in the energy market can be an essential factor in increasing trust.

Further, in addition to the language in the form of words, visualization could also help explain complex issues and ideas in a business context [34]. Thus, we would also argue for using data-driven dashboards and visualizations to help users understand their energy bills and how prices are set.

IV. Conclusions

This paper focuses on the lack of trust among consumers and prosumers in the energy market. The aggregator/prosumer model presented in Fig. 3 can become essential to the transition to renewable energy. Flexibility can help balance the grid and flatten demand curves at peak hours. Trust is crucial for implementing flexibility, where an aggregator can take control over household consumption.

A survey among early adopters of smart home technology shows that actors will meet strong barriers when getting consumers and prosumers on board. The lack of trust has been present since the deregulation of the Norwegian power market in 1971. The common opinion is that energy actors are more interested in earning money than creating the best situation for consumers and prosumers. Several measures need to be put in place to gain the trust of consumers and prosumers. We point to four essential pillars of trust: regulatory measures, technical measures, and organizational transformations combined with adopting a plain language policy. These measures may help build the necessary trust to make flexibility work.

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