Local Electricity and Flexibility Markets: SWOT Analysis and Recommendations

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Abstract—After the millennium's shift, academic study has systematically researched the Local Energy Market (LEM) and Local Flexibility Market (LFM) principle to promote Europe's energy transformation. However, the use of LEMs in real-world programs did not begin until 2016. Towards this direction, the PARITY European project is actively researching and developing a hybrid market model, attempting to merge these two concepts. In this attempt, the current paper offers a market participant-oriented SWOT study, investigating what the strengths and weaknesses of traditional energy models are, as well as identifying what opportunities and threats such hybrid model could phase. Following a number of responses from market participants across Europe, the authors identified also a number of potential conflicts of interest among the market players. The authors aimed to contribute to the scientific community by offering a number of recommendations and ideas that could potentially address the perceived conflicts of interest and serve as the foundation for further research and experimental assessment within the research, academic, and business communities.

Keywords—local energy markets, flexibility markets, SWOT, conflicts of interest, recommendations, renewable energy

I. INTRODUCTION

Considering that modern world utilizes a large quantity of energy, the energy sector is extremely significant. Customers are provided with power as part of the utility value chain and pay on a per-unit-consumed basis. Thus, grid procedures and energy pricing have minimal influence on real energy demand since system imbalances typically occur quickly over short periods of time as a result of inaccurate estimates or unanticipated events [3]. Non-predictable energy generation from renewable raises crucial challenges in grid management, making grid deflection a rapidly increasing issue to existing local market models. Due to the growing energy development, research during the last recent years, as well as the environmental, energy and climate targets set by the European Commission (EC) (target to be fulfilled by the end of 2030) [1], many new models (e.g. Local Energy Markets, Local Flexibility Markets) and technologies have raised, prompted by the need to best reflect the incorporation of intermittent renewable sources. Towards the reach of the 2030-targets, the widespread adoption of Renewable Energy Sources (RES) lays the groundwork for the development of Local Energy Markets (LEM) and Local Flexibility Markets (LFM). LEM allow local exchange of energy between prosumers [2], while LFM are versatility marketplaces primarily serving Distribution System Operators (DSO) needs [4].

Local energy markets have the ability to redesign the energy grid [5] by effectively integrating small-scale prosumers of intermittent solar generation and individual customers into the energy supply chain. The main distinction between LEM and current market models is that market players will benefit from favorable local market rates. Prosumers (i.e. producers and customers) can earn extra income by trading their energy directly to individual consumers. Local electricity markets will also limit the need for costly and controversial grid growth.

Similarly, LFM vary significantly from conventional markets in several ways. Since a service in an LFM can only be provided by units in specific areas, the location - specific component is critically valuable [6]. Furthermore, while the main goal of tradition al energy markets is to stabilize the power system, the primary objective of LFM is to relieve congestion. LFM are yet to be widely developed, and there are only a few programs in the early stages [7]. This work has been carried out within the Horizon 2020 project PARITY, which is currently investigating a hybrid solution, by combining LEM and LFM [8]. The project aims to enable the set-up and operation of LFM at distribution network level. A smart contract-enabled and blockchain-based market platform is being developed to facilitate both P2P energy transactions as well as selling/purchasing of flexibility to different market participants. While the opportunities of blockchain-based energy market platforms have researched from the academics a lot during the last years [22,23], the business opportunities arising in this field will be identified and tested (through the PARITY projects) in four 100 pilot sites all over Europe.

While there are a couple of studies which provide a comprehensive SWOT analysis in the area of renewable energy development and transition [24,25], there is a lack of research in the area of LEMs and LFM specifically. Trying to bridge this gap and compared with other similar papers, our work presents several new aspects. The main contributions of this paper are the following:

- A comprehensive comparison between traditional models and LEMs/LFM.
- A market participant-oriented SWOT analysis, focused specifically on the emerging concept of LEM and LFM.
- A detailed presentation of identified conflicts of interest between the various participants in a hybrid LEM/LFM model.
- A set of recommendations on tackling conflicts of interest between the different market participants to be used as basis for further research and experimentation.

The organizational structure of this study is as follows: Section II presents a brief description of the followed methodology. Section III provides a comparison between the conventional energy market models and the hybrid LEM/LFM model currently under investigation within the PARITY project. Section IV presents the SWOT analysis and discuss its results, while Section V provides a high-level set of recommendations. The paper concludes by providing key take-aways in Section VI.

II. METHODOLOGY

The focus of this study was to gain awareness of the main advantages or disadvantages of the emerging LEM/LFM models. In order to do so, the authors followed a four-step methodology as depicted in Fig. 1. The present analysis begins with a comparison of the conventional energy model with LEMs/LFMs, providing an overview of what this emerging concept has to offer. Then a market participant-oriented SWOT analysis (the acronym stands for “Strengths, Weaknesses, Opportunities, and Threats”) is presented. Through a disaggregation process, three main steps took place in order to conduct the SWOT analysis:

Data collection: A SWOT analysis matrix was created and distributed in several market participants of different organizations. Each market participant filled the matrix emphasizing on market model parameters and identifying different strengths, weaknesses, opportunities and threats, from an external and internal point of view.

Data aggregation: In the second stage of the SWOT analysis, all the collected data from the individual SWOT analysis matrices were evaluated and combined into the final SWOT table, providing a holistic view of the market participants.

Knowledge extraction - Identification of conflicts of interest: The data of the SWOT table was analyzed in order to extract valuable knowledge in terms of possible conflicts of interest between different market participants, as well as identify which barriers can be overcome by LEMs/LFMs.

Finally, the study concludes with recommendations on possible solution on the identified threats. The authors provide a two-fold recommendation list related to: (a) recommendations on tackling threats for market participants and (b) recommendations on tackling conflicts of interest.

III. COMPARISON BETWEEN TRADITIONAL MODELS AND LEMS/LFMs

The key difference between local market models (i.e. LEM and LFM) and the conventional ones (e.g. wholesale market, retail electricity market), lies in the facts that local markets include additional information such as locational information and some technical requirements. To begin with, it is necessary to clearly differentiate LEM and LFM. LEM allows local exchange of electricity between prosumers, while LFM are versatility marketplaces primarily serving DSO needs [4].

Technology-driven improvements apply, among other things, to consumers who have access to in-house energy systems that can produce and store energy and control their consumption profiles. In comparison with the current electricity models, technological advance facilitates a move towards a smarter Local Market model, described as a combination of enabling technologies, hardware and software that collectively make the grid delivery infrastructure more scalable, safe, accommodating, resilient and ultimately useful to consumers. The proposed Local Market model within PARITY project, which combines LEM and LFM, empower users to take an active price-based decision on their electricity consumption. Consumers also have access to emerging technology such as solar panels, batteries, heat storage systems and smart metering devices. The consumer is becoming an active -maker instead of a price-maker. Instead, within current decision models loading is taken for granted and generation has to be changed to preserve system balance. Although current systems concentrate on a market where generation meets demand needs, the LEM/LFM framework sets out new market mechanisms to take advantage of the emerging innovations available (e.g. game theory, auction theory, constrained optimization and blockchain) in both consumption and generation domains. The manner in which markets are structured, determines what entities have access to flexibility tools at different times and locations. Market design improvements are important to allow flexible service providers access to customers that value the services provided. Table I, presents the key differences between current models and proposed Local Market models within the PARITY project.

IV. SWOT ANALYSIS

In this section a market participant-oriented analysis in order to investigate the gaps, evaluate the identified barriers between the current electricity market models and the emerging LEM/LFM model as presented within the PARITY project. Moreover, as an outcome of the SWOT analysis possible conflicts of interest between the market participants will be derived.

A. Materials and Methods

In this sub-section a SWOT analysis focusing on market participants perspectives on the above-mentioned subject is provided. A SWOT analysis is well defined strategic planning to assess the current status of a product in the market
by evaluating its strengths (S), weaknesses (W), opportunities (O), and threats (T) [9]. The SWOT analysis methodology was initially developed for business and marketing evaluation, but it has since been widely used in other research areas, including energy management [10]. The product's/functionality's internal indicators are its strengths and weaknesses, while its external indicators are its opportunities and threats. Strengths are variables that can improve the overall results, while weaknesses can reduce productivity, effectiveness, and competitive advantage. Opportunities are possibilities that can contribute to growth, while threats are concerns that can cause challenges and/or risks [11].

The conducted SWOT analysis in this paper aimed to assess the current status of hybrid LEM/LFM models in the energy market. Therefore, the internal indicators (strengths, weaknesses) were focused on the currently available energy models, while external indicators (opportunities, threats) were focused on the hybrid LEM/LFM model, currently under investigation within PARITY project. The SWOT analysis results were derived by market participants through a set of guiding questions resulting in individual SWOT tables. After combining all the outcomes, a holistic SWOT table was provided. Finally, based on the market participants’ perspectives a set of identified conflicts of interest between different market actors is provided in the following subsection. The differences between the conventional electricity market model and the local market addressed in this paper are significant. In order to evaluate them, each one of the involved experts has conducted an individual SWOT analysis emphasizing on structural parameters and identifying gaps, considering the current market models and the envisioned LEM/LFM.

While conducting the SWOT analysis, the authors prepared the following queries regarding the internal and external parameters (strengths, weaknesses, opportunities, and threats), which all participants used as a baseline. The SWOT was accompanied by answering the following questions through the detailed survey of the working papers, national energy reports and statistics, newspaper articles, academics journals: (a) What advantages conventional energy models have? (b) What improvements could take place to make conventional models more efficient? (c) What LEM/LFM model has to offer more? (d) What people in your market area consider as strength in the conventional market model? (e) What opportunities and obstacles LEM/LFM are currently facing? (f) What are interesting trends you are aware of related to LEM/LFM?

B. Results and Discussion

The results of the SWOT analysis are depicted in Fig. 2 and discussed in the following sub-sections.

1) Strengths: Essentially, the interconnected power grid forms the electrical grid enabling the transfer of energy from the region of surplus to the deficit zone. The conventional electricity market model allows electricity to be generated at the most productive and cheapest power station at all times. As a result, the conventional model is a well-established network with technology providers, decision-makers and customers, that helps the market participants to optimize their operations. The most significant strength of the conventional model is that there is no disruption of the electricity supply if there is a significant failure or planned repair of a generating station in an integrated system. Moreover, it is highly important that there is an established integration between technological aspects and social/legal aspects and extended knowledge and expertise of regulatory aspects. From an economical perspective, traditional energy grids face economic development mainly driven by investments, ensuring economical operation. Specifically, it is because load sharing between stations is structured in such a manner that more productive stations operate at a high load factor continuously throughout the year, and the less productive ones operate only for peak load hours. Finally, an important strength of this model in terms of security is the fact that there aren’t any grid operators or suppliers ensuring safe-guarding of the consumers’ interests.

2) Weaknesses: Historically, distribution grids were built for delivering electricity from centralized power plants to dispersed consumers with limited energy needs. Back then, a one-way communication of power grids was enough, in order to manage the energy demand. Therefore, in the modern society, with the ever-growing energy demand, a stronger distribution system that can cater for the ever-growing demand and also feed-in of electricity is needed. Currently, in the established market model, customers can not actively control their spending and potential prosumers are hesitant to deploy distributed generation and flexible loads in such an environment. There is a lack of ability in planning DER penetration and contemporary flexibility engagement, 415 as well as the risk of getting too much production which has to be (partially) switched off for avoiding over-voltage. Last but not least, the conventional market model lacks the appropriate optimization systems, needed to properly integrate multiple DERs, thus comprising a challenge to aggregators.

3) Opportunities: LEMs should be structured to give participants the freedom to select their energy source and price. In an LEM prosumers are able to sell the surplus
generation to their neighbors at a price higher than the fixed feed-in tariff but lower than the cost of the electricity supplier. Consequently, prosumers gain higher profit for the electricity they generate, and local customers receive energy at a price cheaper than the price of the energy supplier, reducing the energy bill for all sides. In addition, grid operators benefit from LFMs. The advent of DERs such as solar panels and EVs has provided grid management complexities. In order to provide patterns of home electricity use and predict the amount of energy needed to supply and balance the grid, energy suppliers and grid operators depend on regular load profiles. By delivering versatile services and the potential for innovative business models, LFMs continue to alleviate this demand also for electricity retailers and other industry players. Instead, surplus output that would create a peak in the grid would first satisfy local demand, smooth the demand curve of the grid and minimize the need to change production (operational costs) or invest in grid infrastructure (capital costs).

4) Threats: LEMs are expected to play a crucial role in the integration of DERs, emerging technologies and the inclusion of “smart” prosumers in the electricity supply chain. Additionally, many of the proposed models for LFMs envision a role for the DSOs to coordinate and/or be the procurer of flexibility services. However, further clarity on the future role of the DSO in managing flexibility services will be required. To begin with, local flexibility markets, including the proposed one, envisage the role of DSOs in managing flexibility services and/or facilitating them. Also, the complex and incomplete regulatory framework, standards and administrative requirements could have a negative effect in the market participation, especially for smaller energy prosumers. The latter is more important, considering also that many prosumers are not interested in taking key decisions about their own energy use (e.g. behaviors of interest, trading as an individual vs trading as a group, automated trading) [12]. From an economic standpoint, as derived from the SWOT analysis, the key threat the proposed market model will have to cope with, is the increased complexity in calculation of network charges, especially for peer-to-peer transactions. Lastly, the proposed market model has to be coupled with new technology and organization functions, risking the integration of new emerging technologies and capabilities into the old frame.

5) Conflicts of interests: Since the above SWOT analysis is market participant oriented, different views are provided, examining whether one variable affects another and identifying possible conflicts of interest. Several challenges and threats were identified that different market participants might face in the future, leading to possible conflicts between them.

DSO – Supplier (1): Profits optimization between sold and acquired energy: While the DSO is responsible for maintaining the distribution grid and avoiding congestion, the retailer needs to optimize the profit between sold and acquired energy. Thus, conflicts may arise, considering that price signals (e.g. in a Time-of-Use pricing scheme) or demand response interventions coming from the electricity supplier don’t reflect the grid status and therefore might create congestion in the distribution grid [13].

DSO – Supplier (2): Reliable data exchange increases DSO costs: The collection and processing of data is a responsibility of DSOs. In the new proposed market model, data processing will be required in higher time resolution. This will place pressure on the processes of DSOs, while retailers may benefit from this pattern [14].

Prosumer - DSO: Prosumers privacy: Meter mechanisms collect information on prosumers’ activities. The prosumer though, does not know who owns the information, who can control it, and who can profit from it. Controlling data entails a slew of duties for the DSO. Prosumers’ privacy must be protected at any stage [15, 16].

Prosumer - Supplier: The liability is transferred to the prosumers through dynamic tariffs: Dynamic tariffs are gaining momentum. The probability of price uncertainty is transferred to the prosumers and unwelcome surprises in energy bills can occur [17].
DSO – Aggregator (1): Hesitation to disclose sensitive data: Information sharing is not DSOs’ primary focus, in comparison with data collection that is necessary. When it is required to transmit the data to the aggregator, the DSO may be reluctant or unable to do so because of privacy and data ownership issues [18, 19].

DSO – Aggregator (2): Higher market price: The aggregator may leverage the flexibility prices higher than market prices if it offers services towards the DSO, in order to minimize excess capacity scenarios [20].

Aggregator – Retailer: Losing share of the market: The challenge between these two market participants is that their customer segment may overlap. For instance, where an aggregator operates on the wholesale and retail markets, it does not differentiate in any way from the retailer’s role [21].

In order to sum up, during the SWOT analysis that was conducted, some structural gaps were identified leading to conflicts of interests between the different market participants. In a nutshell the main conflicts were identified between (a) the DSO and the Supplier (e.g. pricing, use of energy storage), (b) the Prosumer and either the DSO or the Supplier, (c) the DSO and Aggregator (e.g. regulations, data sharing, grid stability) and finally (d) the Aggregator and Retailer (e.g. energy forecasting errors).

V. RECOMMENDATIONS DERIVED FROM THE SWOT

A significantly higher proportion of renewable power and renewable storage systems will be used in the PARITY project. The proposed market model would allow the incorporation of emerging technologies like blockchain and smart contracts with existing and new smart grid technologies. Although, during the SWOT analysis several challenges and threats were identified that different market participants are possible to face. In the current section, high level recommendations are provided addressing open issues that need to be considered.

A. Recommendations on tackling threats for market participants

Below recommendations on tackling threats for the LEM/LFM market participants are presented, focusing mainly of standardization, data access, data sharing, market accessibility and efficiency.

Standardisation: Prosumers should have direct access to their energy-related data in order to make an accurate decision when changing suppliers or providers and to make the most of off-chain technological solutions, provided by the PARITY project. Customers should also have control over the use of their personal data by third parties (GDPR compliance).

Data access and data sharing: Better access to accurate data is essential to the market from the relevant market players. It is important to ensure data access and data sharing for equal market competition, while at the same time protecting the privacy of consumers through GDPR compliance.

Market accessibility: A system should be built to ensure a fair and open playing field for all service providers offering explicit or implicit demand response and flexibility services operating in the markets. At least the following problems and values need to be addressed: (a) The market-based approach should be considered, considering all forms of versatility. All market participant should compete under fair remuneration. (b) The functions and obligations of the various parties (especially the new ones) need to be explained and clearly defined.

Market efficiency: Market processes should have appropriate synchronization functions between them for economic efficiency and reliability of supply, particularly where the same assets will provide different services to different market processes. In this way, entirely different business mechanisms should be avoided. Additionally, TSOs and DSOs shall pay particular attention to the application of communication between the various market processes under which they work, such as balance and congestion management. Moreover, guidelines for the allocation of bids (i.e. technical and economic approach) should be straightforward and transparent.

B. Recommendations on tackling conflicts of interest

Below recommendations on tackling conflicts of interest between the different market participants are presented, focusing on the DSOs, retailers, prosumers and aggregators.

DSO – Retailer: There are essential differences regarding the profits between the DSO and the Retailer, especially when it comes to customers’ loads. Thus, a business process should be established that would consider the signals from both the market and system itself, managing possible trade-off in an optimal way. Moreover, reliable data exchange increases DSO costs, meaning that if the demand for quicker sharing of data derives from the legislation, the reimbursement must be adequate to prevent unreasonably high costs that DSO faces. Investment costs for the introduction of an effective data sharing network can be difficult to estimate. Thus, the relevant regulation to faster data sharing should be more sufficient to avoid high costs faced by DSO.

DSO – Aggregator: Information collection is not the central activity of DSOs, but it is important to gather information. If it needs to transmit the data to more than one participant, DSO may be hesitant to do so because it requires additional effort. Trying to solve this issue, suitable regulations should establish in order to securely share information between DSOs and aggregators. Furthermore, if the DSO does not need to validate the energy load, the aggregator can increase the price to unfairly high values, and on the other hand DSO would buy it in order to fulfil its responsibilities on grid stability. Mechanisms that would maintain a price cap on the services provided to the DSO, managing possible trade-off in an optimal way, should also be considered.

Aggregator – Retailer: An aggregator can also be a participant in market. Thus, the need for cooperation vanishes and the aggregator becomes a retailer-aggregator. Both participants will have the same consumer base, which means that competition in energy markets is getting stronger, leading to possible market share losses for one of them. Addressing this issue, emphasis should be given to the incorporation of aggregators into the LFM in order to enhance the functionality of the system. It should also considered that retailer’s priority is to remain on balance for energy consumption. Retailer purchase the estimated quantity of energy from the market. The margin between the acquired energy by the distributor and the selling of energy should be
determined by means of imbalance control. Uncertainty in imbalanced electricity markets could cause potential risks and costs for retailers. Thus, retailers and aggregators should efficiently collaborate for maintaining the grid’s balance.

VI. CONCLUSIONS

The current study provided a structural gap analysis of the emerging concept of LEMS/LFMs. To do so, the authors compared the traditional energy models and the innovative concept of combining LEMS and LFMs, as adopted by the PARITY project. While current electricity market models are focusing mainly on traditional and centralized energy sources, the PARITY market model proposes the wide adoption of renewable energy resources focusing on distributed energy generation. Once the comparison was accomplished, it became apparent that key differentiation exists regarding the structure between the conventional market models and the LEM/LFM model. Thus, a SWOT analysis was conducted, taking into consideration the market participants. The holistic SWOT analysis identified strengths and weaknesses, focusing on the current framework, while the opportunities and threats concentrated on the innovative hybrid LEM/LFM model. It is necessary to state though, that the current SWOT analysis face some limitations. Specifically, the analysis was based on a limited participation survey, targeting at this stage only market participants, involved in PARITY project. Additionally, since the implemented SWOT was oriented towards the market participants and focused on structural parameters, different views and opinions were depicted. Therefore, the authors identified several conflicts between market players, for example between the DSO and the retailer. Finally, considering the insights gained by the SWOT analysis, the authors provided a set of recommendations and solutions that could possible solve the identified conflicts of interest. Thus, the contribution of this study could be the basis of further research and experimental evaluation within the research, academic and industry community.

As a future work, the authors aim to extend the current analysis taking into consideration a wider group of participants across Europe and beyond. Additionally, the future goal of the authors is to determine the key aspects that shape the LEM/LFM growth of a country on a global scale, considering respective strengths, weakness, opportunities, and threats.

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