Where do local markets fit in the current European Electricity Market structures?

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***Abstract*—European electricity markets have been complex since their inception. Policies and technologies advancing renewable integration, consumer empowerment, flexibility, and electrification are reshaping generation and consumption, increasing this complexity. System operators face congestion, voltage management, and redispatch challenges while market actors navigate imbalances and volatility. New market structures, such as energy communities and local flexibility markets, aim to address local energy dynamics and integrate decentralized flexibility. However, their fit within existing market frameworks remains unclear, leading to inconsistent interpretations and regulatory uncertainties. This manuscript presents a graphical classification of local markets, positioning them within electricity procurement (e.g., wholesale) and system operation (e.g., ancillary) services while illustrating their interrelations. Despite their potential, these markets remain in early development, facing regulatory ambiguities, resource limitations, and coordination challenges.**

***Index Terms*—European electricity markets, local energy markets, energy communities, local flexibility markets.**

I. Introduction

Over the past two decades, the European Union (EU) has actively transformed its electricity sector through a series of energy packages. The primary objective remains the establishment of a *"competitive, customer-oriented, flexible, and non-discriminatory"* energy market [1].

The resulting energy market, encompassing the electricity and gas sectors, has been inherently complex since its inception, particularly within the electricity sector [2]. Electricity is a unique commodity that requires real-time physical balance, as electricity must be consumed as it is generated to stay in balance [3]. Consequently, a range of markets have emerged within the European electricity market (EEM) to address the unique challenges of trading and managing electricity, forming a sophisticated structure that continues to evolve [4]. This evolution has been largely accentuated by the most recent energy packages—the fourth, *Clean Energy for All Europeans* [5], and the fifth, *Fit for 55* [6]. These policies prioritize renewable energy integration, consumer empowerment, flexibility, and electrification across sectors such as transportation and industry [7].

As these policies take effect, they reshape traditional energy generation, consumption, and distribution patterns, intensifying the challenges of an already strained system [8]. For example, system operators now face increased challenges, such as managing congestion, maintaining voltage stability, and coordinating re/dispatch at more localized levels [9]. Meanwhile, market participants must engage with intensified imbalances and greater market volatility [10], often stemming from local-level disturbances caused by distributed renewable integration and electrification [11, 12].

In response to these challenges, new concepts emerge to address these new local energy dynamics and leverage decentralized flexibility through programs such as Demand Response (DR) [13]. At the same time, the EU has consistently pushed for introducing any new solution as a market-based solution [14, 15]. Thus, these new concepts emerge as new market structures. Notably, these are local energy communities [16] or markets and flexibility markets [17]. These emerging market concepts are being explored from diverse perspectives in academic and non-academic literature (see Section III). Especially the non-academic but policy-oriented documents [14, 15] are addressing them, and upcoming ones, including the Guidelines for Demand Response [18] and the proposal for Network Code for Demand Response [19]. Nevertheless, as with any emerging topic of increasing significance and a growing body of literature, organizing knowledge presents a challenge. The expanding literature results in overlapping definitions and approaches, which, although common for nascent concepts, can introduce ambiguities that hinder both theoretical understanding and practical implementations.

Furthermore, these emerging market structures often address specific aspects of the electricity sector in isolation, although they can be interrelated. This raises critical about how these emerging markets integrate into the existing structure of the EEM and their interrelation. These questions motivate our manuscript. We base our research on a combined literature review approach to examine these emerging market concepts' similarities, differences, and interrelations. Our main contribution is a simple organizational classification of established and emerging market structures. We illustrate these emerging market structures fit within the EEM, and highlight their underlying commodities.

We structure the rest of this manuscript as follows: In Section II, we outline our research approach. In Section III,

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we introduce our simple organizational classification of established and emerging market structures within the EEM, emphasizing emerging local markets. In Section IV, we discuss some of the observations (i.e., regulatory ambiguities and market integration, coordination, locational constraints and resource limitations, and trends), while in Section V we conclude the manuscript.

II. Research approach

We use a combined literature review approach to develop a graphical representation of how local markets fit within existing EEM structures. Our approach integrates principles from two review types while considering established literature review guidelines.

First, we adopt the integrative review approach outlined by [20]. The integrative review approach suits emerging topics well, allowing us to deconstruct them into foundational elements such as history, policy, key concepts, and their relationships. Second, we rely on a narrative review approach based on [21] to provide timely, opportunistic insights into the field. To enhance transparency and mitigate common pitfalls associated with integrative and narrative reviews, we follow the guidelines of [22] and establish a structured search and analysis protocol. While this protocol defines a clear step process, it is not intended to be a quantitative or systematic review due to the topic's complexity. We illustrate our structured search and analysis protocol in Fig. 1.

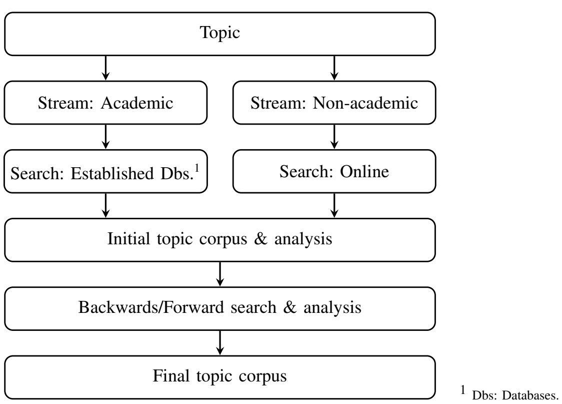

Fig. 1. Structured search and analysis protocol for combined literature review.

We apply our protocol to four topics: energy market structures, energy market classifications, local energy communities, and local flexibility markets. We conduct two parallel search streams: one in academic literature and the other in non-academic sources. For the academic stream, we explore established databases like IEEE, ACM, and Scopus. Our focus is on English-language journals and conference proceedings. We analyze core components such as the title, abstract, and full manuscript when deemed appropriate by the authors. For non-academic sources, we analyze official documentation from EU institutions, including regulations, directives, guidelines, and frameworks. Additionally, we review consultant reports and research projects funded by the EU. We retrieve legal and policy documents from EUR-Lex, consultant reports through Google searches, and research project reports from the CORDIS repository.

Furthermore, we expand our search by analyzing citations (backward search) and identifying subsequent works that cite relevant literature (forward search). Tools like Elicit helped us during these steps. The resulting corpus provides a final topic corpus, which the author team discussed in three meetings.

III. European Market Structures

A. Bird's Eye View

Taking inspiration from the bird's-eye view analogy of [23], we provide a high-level perspective on the current EEM structures. We present in Fig. 2 a simple organizational classification of these markets.

To understand their fit, we focus on the electricity market structures in the EU dealing with electricity as a resource. These have evolved over the past decades to address the challenges of electricity trading and system operation, creating different market structures [24]. These market structures cover various functions, from energy procurement, system balancing, ancillary services, and transmission capacity allocation. We split it in our classification to highlight on the left side of the local markets those that target electricity procurement services, while on the right, those more focused on system operation services.

Within electricity procurement services, wholesale markets operate across various time frames, from forward to spot. Forward and futures markets primarily serve as financial instruments to hedge against short-term price volatility, allowing trading from several years to a month before delivery [25, 26]. Then, despite their name, spot markets are not true financial spot markets [27]. Instead, they enable shorter-term electricity trading, including day-ahead and intraday horizon, with the latter ones having different modalities (i.e., action or continuous). Retail markets complement these trading markets by facilitating electricity purchases for end consumers through energy suppliers.

Beyond these electricity procurement services, electricity markets also include structures focused on system operation services. Transmission capacity markets allocate cross-border transmission rights, enabling Transmission System Operators (TSOs) to manage long-term and short-term network capacity [28]. Meanwhile, capacity markets ensure long-term resource adequacy by incentivizing sufficient generation capacity to meet demand [24, 29]. In parallel, balancing markets provide frequency regulation through primary, secondary, and tertiary reserves, ensuring system stability in real time [30]. Ancillary services extend beyond frequency control and correction markets like redispatching mechanisms [24]. Therefore, we depict connected. Nevertheless, ancillary services can include voltage regulation, black-start capabilities, and interruptible loads, with specific designs varying across countries [31]. However, we chose to illustrate only the main ones.

Local markets emerge at the intersection of electricity procurement and system operation services, functioning as digital platforms that integrate distributed energy resources

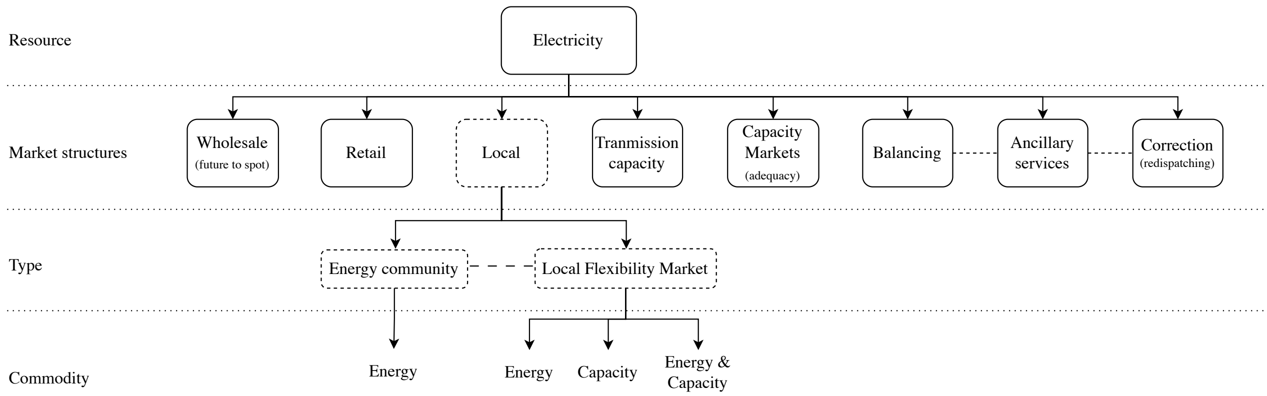

Fig. 2. Simple organizational classification of established and emerging market structures.

while addressing local flexibility needs. We categorize these markets into two main types: Energy Communities (ECs) and Local Flexibility Markets (LFMs). ECs primarily trade energy as a commodity for remuneration [32]. In turn, LFMs use flexibility services, which, depending on the service, trade energy, capacity, or both as a commodity depending on the service [17].

B. Energy communities

The EU defines ECs as collective organizations initiated by citizens to engage in various energy-related activities. These activities include energy production, consumption, and storage, managing energy systems, and trading surplus energy in the market [32]. They can operate various energy assets, including solar power systems, energy storage, and heat pumps [33]. They also employ advanced energy management solutions, such as microgrids, energy hubs, and virtual power plants [32, 34].

Although ECs have existed for decades, particularly in remote areas and islands where fuel access is costly and limited, their role has evolved with the rise of decentralized renewable energy production [35]. The growing adoption of distributed renewables and increasing consumer ownership in energy generation position ECs as an emerging model in modern energy market structures [35].

Officially, the EU distinguishes between two types of ECs: Citizen Energy Communities (CECs) and Renewable Energy Communities (RECs). CECs are legal entities based on voluntary and open participation, controlled by natural persons, local authorities, or small enterprises. Their primary purpose is to provide environmental, economic, or social community benefits rather than financial profits [15]. RECs, a subset of CECs, operate under an enabling framework designed to facilitate their development [35]. They focus on renewable energy projects and are controlled by members located near the project sites. While their goals align with those of CECs, they are explicitly tied to renewable energy sources [36].

Despite these definitions, ECs share several core features. They require a legal entity as their governing body, participation must be voluntary and inclusive, and their primary objective must extend beyond financial gain. Specific governance rules apply, ensuring that certain participants maintain ”effective control” [37]. For instance, natural persons, local authorities, and small enterprises can participate in both CECs and RECs, whereas large enterprises are restricted from joining RECs [38]. These communities often form partnerships between citizens, small businesses, and local authorities, promoting decentralized energy governance [39].

Although EU directives define ECs, Member States (MEs) are responsible for transposing these definitions into national legislation. This has resulted in significant variations in implementation across countries. Some MEs do not differentiate between CECs and RECs, while others integrate collective self-consumption within the EC framework [37].

Consequently, ECs adopt diverse business models [40]. Cooperative models are prevalent, emphasizing collective ownership and democratic governance. Additionally, innovative models such as Peer-to-Peer (P2P) energy trading and virtual power plants leverage digital technologies to enhance energy management and market participation. Nevertheless, they always operate from the point of view of energy, being this their commodity, in other words, what is traded (see Fig. 2).

ECs function as both market actors and market creators [41]. As market actors, they engage with existing electricity markets (see Fig. 2), pooling resources to participate in market mechanisms such as selling surplus energy, demand response programs, and grid services. This enables them to access opportunities typically reserved for large market players, contributing to a more decentralized and democratized energy sector [42].

Beyond participating in existing markets, ECs can act as market creators by establishing new trading platforms, particularly in local contexts [41]. Their services range from energy sharing and self-consumption to grid services for stability and optimization [32]. For instance, using distributed ledger technologies solutions allows for decentralized energy trading within microgrids, commonly referred to as P2P energy trading [43]. These P2P trading can take three forms: fully decentralized, community-based, and hybrid. In fully decentralized

P2P models, energy and financial transactions occur directly between members without intermediaries, allowing consumers to set prices and trade energy independently. While this approach maximizes consumer autonomy, it poses scalability challenges and requires significant computational resources. Community-based P2P models, by contrast, rely on a central entity that optimizes energy exchange within the community, prioritizing collective efficiency over individual preferences. Hybrid models combine elements of both, enabling cooperation between individual peers and centralized coordination, balancing flexibility with efficiency [32]. However, ECs can also contribute to energy system flexibility. Authors in [44] highlight how local ECs can provide flexibility services, linking them to energy efficiency measures and LFMs. Similarly, authors in [45] propose a model for integrating RECs into flexibility markets, enhancing the coordination of distributed energy resources through nanogrids and small-scale storage. Meanwhile, authors in [32] identify two primary market structures for EC-based energy trading: Local Energy Markets and LFMs. It is in this context of literature that the interrelation between ECs and LFMs appears through flexibility services. While with the potential of creating their local markets, these markets might also require flexibility services to provide them internally or beyond the community.

C. Local flexibility markets

LFMs have emerged to integrate decentralized flexibility resources into electricity markets while addressing distribution-level congestion [46]. Their definition varies across contexts, with academic literature viewing them as platforms for trading flexibility within distribution networks [47]. At the same time, regulatory frameworks emphasize market-based procurement to enhance grid efficiency [15]. From a regulatory standpoint, the EU Clean Energy Package (CEP) promotes flexibility procurement through smart meters, digital platforms, and demand-side participation. However, due to their localized nature, LFMs pose risks of market power concentration, requiring regulatory safeguards under Directive (EU) 2019/944 [48].

A typical LFM involves three main participants: flexibility sellers, flexibility buyers, and the market operator (MO) [49, 50]. Flexibility sellers, often referred to as flexibility service providers (FSPs), include aggregators, generators, consumers, and prosumers. The flexibility buyer, typically a Distribution System Operator (DSO) but not limited to, assesses grid conditions using congestion forecasts and procures flexibility accordingly. Across various horizons (e.g., long-term to short-term), DSOs or TSOs may acquire additional flexibility, for instance, for ancillary services or correction ones (see Fig. 2). The MO ensures bid reception, market clearing, and settlements, facilitating efficient transactions. Some clearing models also incorporate Balance Responsible Partys (BRPs) and additional intermediaries [51].

LFMs primarily mitigate distribution network constraints by utilizing Distributed Energy Resources (DERs), such as DR, battery storage, and distributed generation using flexibility services [52, 53]. We remark that these flexibility services defer grid reinforcements. Flexibility services allow power generation or consumption modifications at specific nodes in predefined time intervals, enhancing local balancing and grid stability [54, 55].

Flexibility products within LFMs vary by activation conditions and timeframes. Real-time flexibility (e.g., "PowerCut Urgent") provides immediate grid support, while baseline-based flexibility ("Drop-by") adjusts consumption relative to expected levels [56]. Flexibility option contracts establish agreements where providers commit to demand reductions under specific conditions, while long-term capacity limitations require consistent electricity use reductions.

Market structures and coordination models differ across LFMs. Some are fully centralized under TSOs, while others operate under hybrid TSO-DSO frameworks or are entirely DSO-managed [57]. Their design depends on national flexibility needs, congestion patterns, and existing market structures.

Several business models have been proposed to structure LFM operations. Authors in [55] describe a framework where BRPs and DSOs procure flexibility from aggregators, balancing system-wide and local grid requirements. Authors in [58] present a market-driven approach with DSOs, a market platform, aggregators, and DERs owners coordinating congestion management via auctions. Other studies explore strategic frameworks that integrate trading platforms, automated market clearing, and settlement mechanisms to streamline flexibility transactions [51, 57, 59].

IV. Discussion

We highlight key observations and areas for discussion based on our experience drawn from our approach.

A. Regulatory ambiguities and market integration

A major challenge for ECs and LFMs is the lack of clear and consistent definitions across EU MEs. In the case of ECs, the EU formally recognizes CECs and RECs, yet it does not explicitly define ECs as local entities. This ambiguity leads to inconsistent national implementations and legal uncertainty for ECs seeking to integrate into existing market structures [60]. For LFMs, regulatory developments are gradually shaping their role as market-based mechanisms for contracting local flexibility [18, 19]. They seem to focus on system services at the distribution level [17]. While they complement established market structures, such as correction markets (i.e., redispatch), their application extends beyond distribution-level congestion management, as they can also provide flexibility to higher voltage levels. Without precise legal definitions, especially in network codes, MEs retain significant discretion in their implementation, creating concept fragmentation across the EU. However, their technical implementation heterogeneity is natural as they deal with local problems. Consequently, definitions must also allow for different solutions rather than impose a one-fit-all solution.

Nevertheless, enhancing their interaction through flexibility services, leveraging complementarities, and addressing shared challenges—while clearly defining their roles within existing markets—could foster the development of more robust and scalable business models.

B. Locational constraints and resource limitations

While leveraging distributed resources brings social, environmental, and locational benefits, it also introduces constraints. Unlike large energy providers that benefit from economies of scale, ECs and LFMs operate at a ”local” level, where resource availability may be limited. This scarcity, compounded by voluntary participation, may persist over time.

For ECs, sustainability and community-driven fairness are key drivers, yet these priorities make it difficult to compete in price-driven markets [61]. Although they can attract consumers in retail markets or secure Power Purchase Agreements (PPAs) through ethical branding, their participation in wholesale markets remains challenging due to cost disadvantages so that business models might disfavor them.

Similarly, LFMs depend on geographically constrained resources, as their current primary function is congestion management at the distribution level [17]. This creates variability in design and implementation across countries, reflecting differences in congestion challenges and flexibility needs [57]. Some LFMs focus on long-term flexibility procurement, while others operate in near-real-time [17]. Yet, all must aggregate flexibility at a local level, requiring the aggregator to be a facilitator for small resources [46]. This raises the question: *how can distributed resources be incentivized to participate in these markets?* Targeted financial mechanisms—such as subsidies for ECs engaging in LFMs or fixed service-specific contracts in tariff-based solutions—could bridge the gap between regulatory intentions and practical implementation, yet this remains an area for further research.

C. Coordination

Effective coordination is critical for managing local energy assets and ensuring market efficiency. While synergies exist between ECs and LFMs, their integration is not mandatory—ECs can function independently, and LFMs do not inherently rely on them. This raises questions about optimizing their interaction to enhance flexibility and operational efficiency. Furthermore, ensuring interoperability requires standardized frameworks for data exchange and process integration, addressing a broader challenge in smart grid solutions.

Beyond ECs and LFMs, coordination challenges intensify in multi-market interactions, such as wholesale markets, balancing mechanisms and ancillary services. The broader issue lies in how shared resources and services can be efficiently allocated across different market structures without creating inefficiencies or conflicts. However, these emerging local markets could contribute to addressing this challenge by providing new coordination mechanisms that facilitate resource-sharing across multiple services.

D. Trends: market-based, user-centric, and platforms

The rise of these local markets is shaped by multiple trends, including market liberalization, user-centric energy systems, and digitalization. Market-driven approaches increasingly dominate, reinforcing the transition toward decentralized, competitive environments where electricity and flexibility are treated as tradable commodities. As regulation continues to emphasize market-based mechanisms, these concepts are likely to evolve into service-oriented solutions. In other words, to enhance their long-term viability, especially given potential resource limitations ECs and LFMs as platforms will offer various services, where flexibility services will be the main link between these two markets.

Consumer-centric-driven energy models are also gaining traction. With increasing DER adoption, prosumers seek to engage in energy markets beyond self-consumption, facilitated by digital platforms and automation. In LFMs, aggregators will likely play an expanding role, pooling resources and introducing new coordination and economic dynamics.

Digitalization is a key enabler of these trends. Smart metering, automation, and distributed ledger technologies-based trading platforms facilitate dynamic interactions between local energy producers, consumers, and grid operators [62, 63]. The result is a trend towards creating platforms for ECs and LFMs. Thus, further research into market coordination mechanisms, data-sharing frameworks, and cross-border exchanges are potential research streams essential for commercializing these solutions.

V. Conclusion

The decentralization of the EEM has introduced new market structures, such as ECs and LFMs, to integrate DERs and enhance grid flexibility. However, these markets remain in early development, facing regulatory ambiguities, resource constraints, and coordination challenges.

Our manuscript provides a structured overview of their integration within existing market structures, highlighting their role in bridging electricity procurement and system operation services. ECs enable direct community participation in energy markets, while LFMs facilitate local flexibility procurement. However, regulatory inconsistencies across MEs create fragmentation, limiting market participation and scalability. Their locational constraints and voluntary nature further restrict resource availability, raising concerns about long-term viability.

Their success will depend on regulatory harmonization, business model innovation, and digital infrastructure advancements. Clearer legal definitions and targeted financial incentives could facilitate broader adoption, while platform-based coordination mechanisms will be key to scalability. Future research should focus on adaptive regulations, cross-market coordination, and digital platform integration to enhance the scalability and effectiveness of ECs and LFMs.

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