# Fundamental Local Energy Sharing and Trading Models

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***Abstract*—This paper proposes a unified classification framework for local energy sharing and trading by introducing six fundamental models that capture the main approaches used in practice, piloted in demonstration projects, and studied in the literature. The framework follows a decision-tree that first distinguishes collective asset sharing, where members co-invest in shared assets (e.g., PV or community batteries) and benefit through predefined capacity, energy, or revenue allocation, from individual asset-based sharing, where participants exchange energy based on their own generation, storage, or flexible demand. Individual sharing is further divided into centralized peer-to-pool/pool-to-peer designs without bilateral matching and distributed designs with explicit peer-to-peer transactions that support counterpart-specific preferences and prices. A broad set of real-world initiatives are then mapped onto the framework, while assessing each model's operational strengths and implementation challenges.**

***Index Terms*-- Local energy sharing, peer-to-peer trading, energy communities, electricity markets, distributed energy resources**

## I. Introduction

Energy communities (ECs) and local energy sharing frameworks are gaining increasing prominence globally and particularly within the European context. Their rise is driven by the potential to foster local renewable energy production, self-consumption, and storage deployment coupled with decentralized energy sharing, thereby enabling the active participation of consumers in the evolving energy system and supporting the broader digitalization and electrification of end-user applications. Realizing the full potential of ECs at scale critically depends on their ability to effectively utilize local energy resources through well-designed local energy sharing and trading arrangements.

A variety of local energy sharing and trading schemes have been proposed in the literature and explored in practice. A number of works have looked into different peer-to-peer (P2P) energy exchange architectures (as surveyed in [1], [2]), while others have focused on different allocation/energy sharing schemes mostly via implemented game-theoretic tools [3], [4], [5], [6], [7]. In addition, a number of works have focused on the grid-impact of local energy sharing by considering differing local energy sharing models as, e.g., in [8] and [9], and governance models for shared generation and storage assets [10]. However, this diversity has produced an ambiguous landscape of concepts and terminologies surrounding local energy sharing and trading mechanisms, thus complicating the classification of different models and hindering a consistent assessment of their benefits, limitations, and operational feasibility. This paper addresses this gap by introducing *six fundamental models of local energy sharing and trading* that form a unifying classification framework encompassing the most common approaches applied in operational ECs, demonstrated in pilot projects, and examined in academic research.

The classification is derived from a decision-tree structure that first distinguishes between: (i) collective asset sharing, in which EC members co-invest in shared assets (such as large-scale PV systems or community battery energy storage systems) and benefit according to predefined capacity, energy, or revenue allocation schemes; and (ii) individual asset-based energy sharing, in which each participant owns their own generation, storage, or flexible demand assets and engages in energy exchange with other members. Within individual energy sharing, the framework further differentiates between (i) centralized and (ii) distributed models. In the centralized scheme, users with surplus energy transfer or offer that surplus to the community, while members with energy shortage draw (or purchase) energy from the community. As such, no bilateral peer-to-peer matching takes place, thus constituting a setting of peer-to-pool/pool-to-peer energy exchange. In contrast, distributed schemes explicitly match peers bilaterally, enabling direct peer-to-peer energy transactions. This P2P matching/trading then enables peers to set different preferences for trading with other individual peers (also including different prices), which is an aspect that is not readily possible in peer-to-pool/pool-to-peer schemes.

These dimensions give rise to six foundational models that together span the design space of local energy sharing and trading. The paper introduces these models and surveys a broad set of implemented EC and energy sharing initiatives, including operational EC schemes, commercial platforms, and demonstration/pilot projects and maps them onto the proposed framework. This analysis demonstrates the applicability of the classification, highlights the operational strengths and

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challenges of each model, and provides insights into their practical implementation potential and challenges.

The remainder of the paper is organized as follows. Section II introduces the six fundamental local energy sharing models. Section III investigates the underlying advantages and challenges of each while mapping real-world initiatives to these models. Section IV concludes the paper.

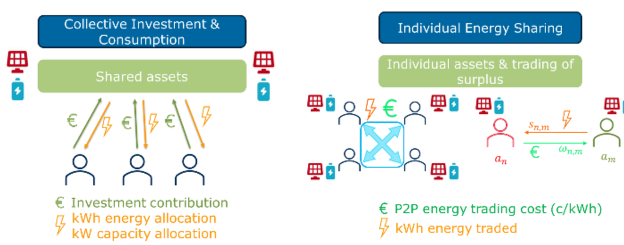
## II. TAXONOMY OF LOCAL ENERGY SHARING AND TRADING MODELS

Next, we introduce six principal models of local energy sharing and trading that form a taxonomy encompassing the common approaches adopted in practice, piloted in demonstration projects, or proposed in academic literature. We first introduce the structure of the classification followed by the six models.

We note that legal classification typically differentiates between local energy sharing and local energy trading, where energy sharing corresponds to a form of collective self-consumption and allocation setting (transfer of renewable energy rights with or without financial compensation), while energy trading refers to the sale of energy between peers. For ease of exposition, we use the terms *sharing* and *trading* interchangeably, while noting this legal distinction.

### A. Structure and Classification

The first classification step distinguishes models centered on *collective* investment and consumption from those based on *individual* energy sharing (Figure 1).




*(a) Collective energy sharing* *(b) Individual energy sharing*

*Figure 1 – Collective and individual energy sharing schemes*

In collective schemes, members co-invest in shared assets, e.g., photovoltaic (PV) or battery energy storage systems (BESS), and benefit through capacity, energy, or revenue allocation. In individual schemes, members own their own generation, storage, and loads, and exchange surplus energy within the community during surplus/deficit periods. These approaches are not mutually exclusive and can coexist within the same EC or energy sharing scheme.

Within individual energy sharing, we distinguish two settings: *centralized* and *distributed*. In the centralized setting, participants with surplus energy offer it to the community pool, while those with deficits draw from the same pool. Thus, exchanges follow a peer-to-pool/pool-to-peer structure rather than bilateral trading. In distributed settings, participants are matched bilaterally, creating explicit peer-to-peer transactions. This bilateral matching allows participants to express counterpart-specific trading preferences, potentially including differentiated prices, which is an option unavailable in peer-to-pool/pool-to-peer schemes.

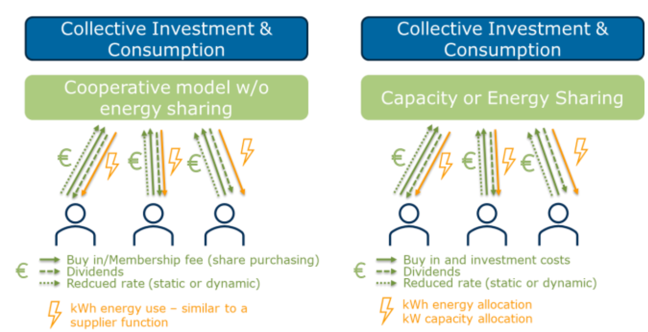
### B. The Six Representative Models

The dimensions defined in Section II.A underpin six fundamental models of local energy sharing and trading. Next, Section II.B.1 presents two fundamental collective-investment models: (1) **cooperative model without energy sharing** and (2) collective **capacity, energy, and revenue allocation model**. We then turn to individual energy sharing, distinguishing centralized and distributed designs. Section II.B.2II.B.2) covers centralized approaches, including (3) **energy sharing at predefined internal pricing** and (4) **auction-based local trading**, while Section II.B.3II.B.3) addresses distributed designs, namely (5) **continuous P2P trading** and (6) **pool-based P2P trading**.

#### 1) Collective energy sharing models

The first collective investment and consumption model is the *energy cooperatives* model (Model 1), which is widely adopted across EU Member States (Figure 2a). In energy cooperatives, members typically pay a buy-in to join the cooperative and may receive dividends. Importantly, however, this model does not involve direct energy sharing among members. Instead, the cooperative acts as a retail supplier: it procures electricity from the wholesale electricity market, via long-terms instruments such as power purchase agreements (PPAs) complemented by actions on the spot (day-ahead and intraday) markets, and supplies it to its members, often at supported rates. Therefore, collective member contributions enable joint procurement and participation rather than explicit member-to-member energy exchange.

The second collective investment-consumption model (Figure 2b), coined the *capacity, energy, and revenue allocation model* (Model 2), explicitly includes energy sharing. Members co-invest in shared assets and seek to distribute the resulting benefits (capacity, generated energy, and/or revenues) among participants. While dividends may still be paid, the core design dimension is the definition of allocation




*(a) Model 1: Cooperative model without energy sharing* *(b) Model 2: Capacity, energy, and revenue allocation model*

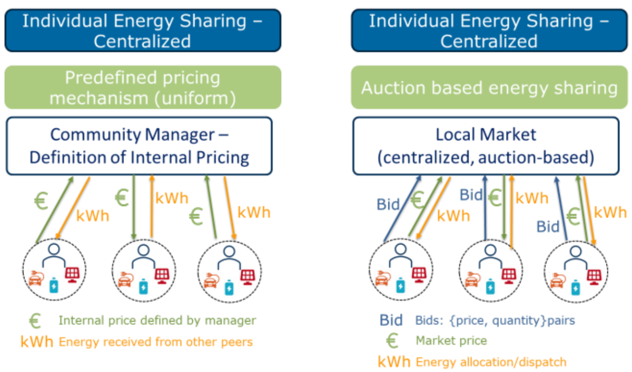
*Figure 2 – Collective energy sharing models*

schemes (allocation keys) that apportion the shared assets' output or capacity across community members.

*2) Individual energy sharing – centralized models*

We now turn to individual energy sharing, where we distinguish between two centralized models and two decentralized, P2P, models.

In centralized designs, participants do not trade bilaterally. Instead, they inject surplus into, or cover deficits from, a community pool, thus constituting a peer-to-pool/pool-to-peer form of local energy exchange. We examine two governance approaches for this internal exchange: (i) an implicit mechanism based on defined internal community prices, and (ii) an explicit mechanism in which participants submit bids and offers in an auction-based local market.




*(a) Model 3: Energy sharing at predefined internal prices*

*(b) Model 4: Auction-based local trading*

*Figure 3 - Individual energy sharing – centralized models*

The first centralized individual-sharing model (Figure 3a), labeled the *energy sharing at predefined internal prices model* (Model 3), relies on predefined internal pricing for community energy exchanges. Each member makes surplus available to the community and/or covers deficits (at least partially) from the pooled surplus, with any residual demand supplied by the conventional retailer. The community manager sets the internal tariff that values these exchanges, so allocation is implicit and driven by the pricing rule rather than by explicit trades. The pricing is typically uniform, thus applied equally to all community members. In some implementations, the pricing rule is applied ex-post: after a settlement period, an accounting process determines the internal price and remunerates injections and withdrawals accordingly.

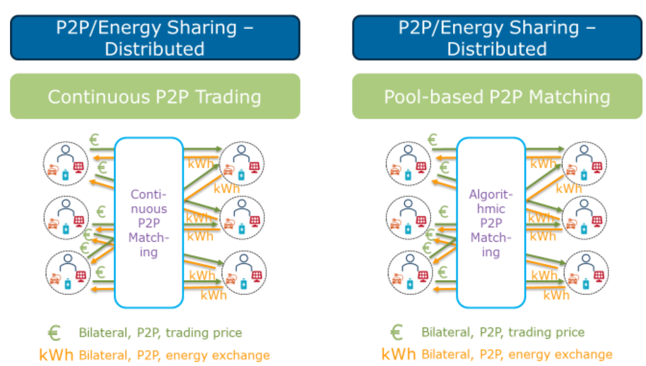
In the next model, dubbed the *auction-based local trading model* (Model 4), shown in Figure 3b, energy sharing is explicit: members with surplus submit sell/ask orders and members with deficits submit buy orders at user-defined prices via bids. The setting remains centralized, but instead of relying on administratively defined internal tariffs, participants place price-quantity bids in a local market. A centralized clearing algorithm, e.g., welfare maximization analogous to day-ahead market clearing while accounting for local user or grid constraints, matches aggregate supply and demand and determines the resulting energy allocations and market price(s). Although trades are explicit, exchanges remain pool-based: individual surplus is offered to a community pool and allocated to deficit members, rather than through one-to-one matching between peers.

*3) Individual energy sharing – distributed models*

The next two models focus on P2P energy trading.

The first, shown in Figure 4a, and coined *continuous P2P trading* (Model 5), consists of continuous bilateral trading between peers: a P2P platform allows peers to post price-quantity sell/ask offers and buy bids to monetize surplus or cover deficits. Participants then select counterparties directly and execute trades on a first-come, first-served basis, in a manner similar to continuous trading in European wholesale intraday markets. As matching is performed by the peers themselves or via simple P2P matching considering defined criteria such as ask/bid spreads and other listed preferences, no centralized, complex matching algorithm is required, and each transaction is bilateral. We note that besides price preferences, community members may consider other attributes (e.g., proximity, energy source) in their choice to match with other members.

The final model captured in Figure 4b, the *pool-based P2P trading model* (Model 6), considers algorithmic P2P matching. In this model, each peer specifies requested trades with other peers, including price, quantity, and additional preferences. Given these offers, where a peer may propose trades with multiple counterparts, a matching algorithm determines bilateral exchanges that satisfy participants' constraints and preferences while enforcing reciprocity (i.e., the volume peer $i$ offers to sell to peer $j$ equals the volume peer $j$ agrees to buy from peer $i$). This matching setting is typically formulated as a game-theoretic problem (due to the interdependence in the feasibility spaces of the optimization problem to be solved by each peer) [5], [9]. A solution algorithm then seeks a P2P matching that corresponds to a game-theoretic equilibrium (mostly a generalized Nash equilibrium), i.e., a set of bilateral traded quantities and prices from which no participant has an incentive to unilaterally deviate, and which abides by the individual and shared constraints.




*(a) Model 5: Continuous P2P trading*

*(b) Model 6: Pool-based P2P trading*

*Figure 4 Individual energy sharing – distributed (P2P) models*

## C. *Classification scope*

These models provide a foundational taxonomy spanning the main local energy sharing architectures observed in practice. These models are not mutually exclusive, as an energy community may combine energy sharing from collectively owned assets with sharing from individual contributions. The taxonomy focuses on local energy sharing and trading, through which peers sell their surplus energy to other peers or cover their energy shortage from other peers, rather than on flexibility delivery to distribution and transmission system operators (DSOs, TSOs). While local energy sharing models can support flexibility delivery, this aspect lies outside the scope of the present classification.

# III. MAPPING TO KEY INITIATIVES

This section maps real-world initiatives, which include energy cooperatives and communities, pilot projects, and commercial platforms, onto the six models of our framework and analyzes the advantages and challenges of each of the models.

## A. *Mapping of initiatives: opportunities and challenges of the different models*

We performed an extensive search for existing energy communities, pilot projects, and related initiatives by reviewing publicly available sources, including targeted web searches, available repositories, and reports on existing EC and energy sharing projects. The geographical scope of the search was limited to Europe. The identified initiatives were then systematically analyzed and mapped onto our model framework. In total, thirty-eight initiatives were identified for which sufficient information was available to classify them within our taxonomy. An overview of the number of identified initiatives and their classification within the framework is provided in Figure 5. The full list of initiatives is provided in Table 1 in the Appendix.

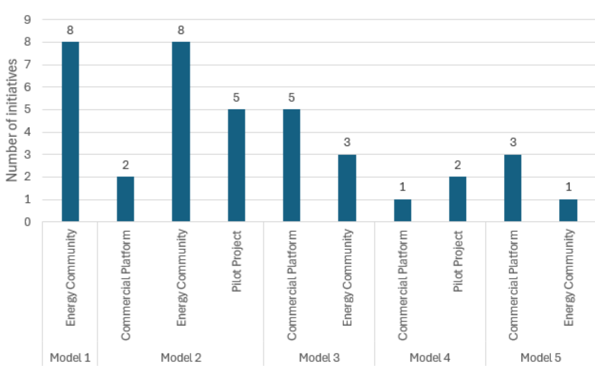



*Figure 5 - Number of initiatives identified under each model, split by operational type*

In our categorization, the term *Energy Community* follows the legal definitions provided in Directive (EU) 2019/944 and Directive (EU) 2018/2001, referring respectively to Citizen Energy Communities and Renewable Energy Communities. *Commercial Platform* refers to platforms operated by suppliers or provided by technology providers that enable end consumers, prosumers, and small local power producers to register and trade electricity. *Pilot Project* refers to a regulatory sandbox, technical testbed, or operational pilot used to test energy sharing or trading mechanisms in real-world conditions.

Out of the thirty-eight initiatives identified, most (around 82%) fall within Models 1, 2, and 3, which represent lower-complexity implementations. These models are also more commonly observed in real-world operational initiatives. More complex implementations, such as those represented by Models 4 and 5, are more frequently found in pilot projects or implemented through commercial platforms, with only a limited number of actual applications within ECs. Due to greater regulatory challenges and higher technical complexity, their real-world implementation remains more limited. Consistent with its high level of complexity, Model 6 was not identified in real-world initiatives in our analysis. While this does not rule out potential pilot implementations, available evidence suggests that Model 6 is primarily explored in academic studies through numerical examples and use cases. For this reason, Model 6 does not appear in the mapping.

Under Model 1, we observe a concentration of cooperative initiatives in which members jointly invest in renewable energy sources. Members receive dividends as a return on their investments, as well as electricity at a supported membership rate, but without explicit energy sharing. As energy sharing continues to face practical obstacles and heightened fees in many EU member states [11], Model 1 remains one of the most standard models of energy communities. In Model 2, operational ECs use allocation keys to distribute collective and jointly-pooled individual energy among members. These allocation keys can take different forms of distribution ratios depending on the regulatory implementation in each country. The most used approach is a pre-allocated fixed share for each member, although an increasing number of initiatives are implementing dynamic keys, where the share of energy received is determined by the consumption profile [12]. Due to its practicality and simplicity of implementation, Model 2 has the widest adoption, covering around 39% of the surveyed initiatives, and spanning different operational types.

Initiatives classified under Model 3 are mostly represented by digital platforms provided by electricity suppliers and third-party technology providers, through which members can market and sell their locally-produced electricity (e.g., from rooftop PV), but without being formally a part of an EC. The price at which the electricity is sold is typically predefined by the platform operator. Nonetheless, several ECs have also adopted this model as captured in Figure 5. In Model 4, higher-complexity implementations become evident and are mostly found in pilot projects. In these cases, members submit bids and offers for locally generated electricity, while a local clearing market determines the final energy allocation and prices for all participants. This entails that members can identify, ahead of real-time operation, their (net) consumption baselines [13] to accurately quantify their surplus or shortage volumes to be traded, which hinders the practical implementation potential of this model. Nonetheless, some initial initiatives adopting Model 4 as part of commercial platforms are starting to appear, by relying on either advanced digital tools or longer time spans for energy commitments (i.e., buy/sell contracts), which reduce the need for dynamic baseline identification close to real time.

Initiatives identified under Model 5 are predominantly implemented by commercial platforms. Such platforms allow users to choose with whom to exchange energy based on price and other criteria (e.g., location, energy source), in the form of continuous first come, first served bilateral trading, thus reducing the need for complex matching algorithms (which would have been the case under Model 6). As such, this significantly simplifies their operation (as compared to Models 4 and 6), thus supporting their practical implementation. In practice, implementations of both Model 4 and Model 5 are often also supported by blockchain-based platforms that enable transparent electricity trading.

While the main drivers for end users to engage in energy sharing are financial benefits, environmental motivations, and energy independence, the main barriers remain cost-based, legal, and technical complexity. This is reflected in the distribution of the identified initiatives across the different levels of technical and, by extension, regulatory complexity represented by the models.

### B. Additional Key Reflections

In general, any model based on explicit energy offers (Models 4-6) requires end users to quantify a baseline in order to estimate expected surpluses and deficits over time and formulate bids and asks. While these models enable active participation, support extended user autonomy, and can improve local market efficiency, their implementation is challenging as they place substantial forecasting and decision complexity on users. By contrast, Models 2 and 3 typically entail lower user-side complexity. Considering differing energy buy/sell commitment durations and forms of pay-as produced P2P energy sharing contracts can ease the complexity of baseline calculations, and risks thereof, thus further supporting the practical implementation of sharing models of higher complexity.

Across local energy sharing models (Models 2-6), the timing of sharing actions can affect third parties, most notably suppliers and balance responsible parties (BRPs). For instance, higher self-consumption can reduce a supplier's delivered volumes and revenues relative to already procured energy. Moreover, if sharing occurs after day-ahead commitments, especially when participants belong to different BRPs, it can shift net positions and create BRP imbalances, potentially triggering imbalance charges. These interactions should therefore be considered when designing local sharing rules and mechanisms. In practice, analogous correction mechanisms have been proposed for flexibility aggregation and could be adapted to local energy sharing [14]. Such mechanisms can serve to reduce the heightened fees already common in several European member states, which constitute a direct hurdle to the implementation of local energy sharing and trading [11].

## IV. Conclusions and Outlook

This paper has consolidated the diverse landscape of local energy sharing and trading into a coherent taxonomy of six core models. The classification separates arrangements based on shared community assets, with benefits distributed via predefined allocation rules, from member-owned assets, where exchanges arise from individual generation and storage assets. For the latter, a clear distinction is introduced between pool-based centralized designs and bilateral peer-to-peer designs, the latter enabling differentiated counterpart trading choices. Mapping a wide range of operational schemes and pilot initiatives onto this structure corroborates the representativeness of the six models and enables consistent comparison across implementations, highlighting key operational trade-offs and deployment barriers. Notably, lower-complexity models (Models 1-3) appear far more prevalent than more complex models (Models 4-6), even though the latter can support more autonomous and explicit local trading, but suffer from a high complexity level.

The analysis in this paper is a first step towards a more general available database of different ECs and local energy sharing initiatives, including description and justification of different design choices and success features, which would be of key importance to support the foundation and upscaling of ECs and local energy sharing and trading in Europe. This effort constitutes a key future research direction.

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## Appendix

*Table 1 - List of initiatives. EC: Energy Community; CP: Commercial Platform; PP:Pilot Project*

| Name | Operational type | Model |
|---|---|---|
| Brixton Energy | EC | 1 |
| Coopernico | EC | 1 |
| Ecopower | EC | 1 |
| Edinburgh Community Solar Co-operative | EC | 1 |
| Energiecoöperatie WPN | EC | 1 |
| Jurascic | EC | 1 |
| MegaWattPuur | EC | 1 |
| Som Energia | EC | 1 |
| Grid Singularity (Community Sharing) | CP | 2 |
| Yuso | CP | 2 |
| Brupower | EC | 2 |
| Communauté D’énergie Terdelt | EC | 2 |
| Greenbizz.energy | EC | 2 |
| Illuminons notre quartier | EC | 2 |
| Klimaan | EC | 2 |
| Quartier Chomé | EC | 2 |
| Vallevignale | EC | 2 |
| Valverde | EC | 2 |
| HospiGREEN | PP | 2 |
| Les Petits Riens | PP | 2 |
| Partag’élec | PP | 2 |
| Sunshare | PP | 2 |
| Ville de Hannut | PP | 2 |
| Bolt Energy | CP | 3 |
| LUOX Energy | CP | 3 |
| Powerpeers | CP | 3 |
| SonnenCommunity | CP | 3 |
| Vandebron | CP | 3 |
| Energie VanOns | EC | 3 |
| Energiecoöperatie Slim Strandnet | EC | 3 |
| om nieuwe energie | EC | 3 |
| Grid Singularity (Local Energy Market) | CP | 4 |
| Pebbles | PP | 4 |
| Quartierstrom | PP | 4 |
| Grid Singularity (P2P Trading) | CP | 5 |
| smartCOMMUNITY | CP | 5 |
| SunContract | CP | 5 |
| OurPower | EC | 5 |

The classification is carried out to the best of the authors’ knowledge given publicly available information via the websites and documentation of the different initiatives.