Value streams in different energy community types – Review and Implications

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***Abstract*—Energy communities are being implemented in the EU member states, but due to national differences and understandings of the concepts, the overall business landscape remains hard to grasp. This paper reviews the literature on energy community value streams and points these to different energy community types and country implementations. Energy communities using the public grid offer more pathways to system-related services, yet models based on property boundaries are rather based on self-consumption. We discuss the implications of studied differences on the customer journey, service providers' business models, and surrounding regulatory institutions.**

***Index Terms*-- Collective self-consumption, demand response, energy communities, value streams, regulation**

I. INTRODUCTION

Recent European directives for energy communities (ECs) are being transpositioned by the member states, and the whole EC sub-sector is taking shape. The directives of Citizen Energy Communities (CECs) [1], Renewable Energy Communities (RECs) and Jointly Acting Renewables Self-Consumers (JARCs) [2] have been accommodated to local institutions on different scales; whereas some countries put ECs in a central position in their energy strategies, other countries have less interest in developing them. Indeed, the directives leave a lot of flexibility for the member states in EC implementation.

ECs have been categorized in different ways, according to the legal form, technology, geographical boundaries and coordination mechanisms, for example. However, for the EC sector's large-scale diffusion, there needs to be a better understanding of business model opportunities in various contexts. Even though there is a wide literature on EC business models and regulatory forms, making sense of the European-wide business landscape remains challenging [3], [4]. The directives and concepts have been interpreted differently, and the prevailing institutions, e.g., on land use, housing, and infrastructure, accommodate ECs in different ways. Understanding similarities and differences across different contexts requires standardization of concepts related to ECs. A better understanding of EC business models helps service providers to develop their services, gain access to finance and related numerous EU programs [3], and share best practices among regulators and policymakers.

II. METHODOLOGY

Recently, a wide academic literature on EC regulations and business models has emerged [3], [5]–[14]. This paper reviews these articles from the value streams and EC types perspectives. Namely, we overview the different value streams of ECs in relation to the energy systems and link them to different energy community types, depending especially on the distribution system operator's (DSO's) role, EC's locality, and relation with the property boundaries. This typology is previously introduced by Valta et al. [15], and it is shown in Figure 1 (in Appendix).

The handled value streams are related to the electricity system (as in [16]) and, therefore, do not represent all possible value streams that ECs can offer, for instance, improved energy performance certificates or increased property value. The studied value streams can be quantified in monetary terms, although, they can bring also social and environmental value to the customer. In the Discussion chapter, we discuss the implications for EC members, business model creation, and surrounding regulatory institutions. An overview of the results can be seen in Table 1, in the Appendix of this paper.

III. ENERGY COMMUNITY TYPES

A. EC type A: Front-of-the-meter EC within one property

The directive on JARC refers to "A group of at least two jointly acting renewables self-consumers [...] who are located in the same building or multi-apartment block" [1]. ECs operating within a single property area can include housing companies, shopping centers, university campuses or hospitals. They are usually connected to the grid by one point of common coupling. Members of the EC have their own electricity retailers, and the DSO provides smart meters for them. ECs within a single property have traditionally been able to self-consume only the unit loads in shared or common property, such as elevators, corridors and common areas. Yet, these are highly dependent on the building characteristics [17]. Recent legal changes in many countries have changed this, and nowadays, members can offset individual apartment loads in-front-of-the-meter. Often, collective self-consumption leads to savings from grid fees, but there are different approaches to handling taxes and levies [18].

B. *EC type B: Behind-the-meter EC within one property*

A behind-the-meter EC can be used in similar contexts as type A, but as a difference, there is only one DSO meter for the whole community. Members of the EC have the same electricity retailer, and they also arrange the sub-metering and billing by a separate service provider.

In some countries, the EC types A and B can also include a production unit on a neighbouring plot by connecting it with a direct line without forming a ring topology.

C. *EC type C: Own grid*

The European directives on CECs have some exceptions that allow ECs to own the grid in some special cases. These are also called microgrids or "private wires" [7]. Article 16 [1] states that Member States can provide enabling regulation for ECs to "own, establish, purchase or lease distribution networks and to autonomously manage them". They may also decide to grant CECs the right to manage distribution networks in their area of operation and establish the relevant procedures", yet, they need to follow the same regulations applying to distribution system operators. One case is an industrial/commercial area with a Closed Distribution Network. Some countries, such as France and Italy, have some local integrated utilities that can be seen as ECs with their own grid. A small DSO with a grid concession agreement in Portugal can purchase and resell power to customers [19]. Yet, these models are mainly not meant for commissioning new ECs [19], [20]. In these cases, the EC manages the grid, metering, and billing and has one common point of coupling with the DSO's grid. Electricity consumption is subject to taxation. However, what happens behind-the-meter is largely unregulated, so the service providers with the EC members have to create their own local rules [7].

D. *EC type D: Local virtual EC*

The local virtual EC refers to ECs that are geographically bounded, but include different property owners and use the public grid to transfer electricity through virtual metering [e.g., 4]. Usually, there is a substation or other point of common coupling for the EC, and therefore, this EC type D can support the local distribution network. The members in such local EC have their own contracts with a retailer and a DSO, who also provides the metering. Several self-consumption schemes include savings from unused transmission and distribution networks.

E. *EC type E: Distributed virtual EC*

In the distributed virtual EC, the EC members can be located geographically further away from each other, even in different DSO areas. Such non-place-based ECs include virtual power plants, and cooperatives that produce, sell and supply energy. From the European directives, only the CEC applies to this EC type as it does not set any proximity requirements.

IV. Value Streams in Different Energy Community Types

A. *Collective electricity purchasing and guarantees of origin*

Collective electricity purchasing adds to the negotiating power of individual members by allowing them to quote for a larger quantity in a single agreement. In contrast, also the retailer gets a larger customer base and revenue with a single contract while saving transaction and customer acquisition costs. The contract can be a fixed, dynamic or hybrid contract type.

Regarding the different EC types, there are no barriers to collecting an interested group of households or companies and negotiating and purchasing a collective electricity contract. This happens usually through a third-party facilitator. [21] Similarly, cooperatives can buy shares in an RE plant, whose operator allocates certificates of origin to the members at a dedicated tariff [9]. This is not, however, self-consuming because there is not necessarily a link between the timing of production and consumption. Such projects can work as crowdfunding projects where citizens can buy shares in.

In the context of ECs, the interest of having one shared retail contract may arise in cases where EC members are part of the same property, and in that way, can save in network tariffs by having one DSO contract and metering point. In that sense, the types B and C are more likely EC types for attaining this value stream.

B. *Selling collectively owned production*

The EC can also invest in its own electricity production, which can be sold to the electricity markets. In production-based ECs (especially type E), this means selling all the production to a retailer, often via a feed-in tariff or other compensation. In ECs aiming for self-consumption (EC types A-D), this means rather selling the production that exceeds the local consumption. The compensation for the excess production is the wholesale price, a feed-in tariff, or it may include tax reductions or other surcharges [6].

C. *Distributed virtual self-consumption*

In virtual self-consumption, the production outside the EC is metered and allocated to its self-consumer. For instance, leasing a solar PV panel in another, still, often close-by location can allow citizens to participate in the energy transition if they do not have appropriate conditions themselves. Or, some wind developers offer local people a special tariff for the production to increase local acceptance of the project [20], [22]. Some countries have implemented or thought of virtual net metering schemes in which the same owner entity can transfer excess generation credits to other consumption points [8], [23]. There are also different peer-to-peer (p2p) schemes or local energy markets (e.g. SonnenCommunity) and energy provision/matching that happen in-front-of-the-meter, such as Vandebron [6], [10].

Due to the distance between the production and consumption locations, the virtual self-consumption does not support grid management. It can be implemented in all EC types, for example, through previously mentioned companies' platforms. However, virtual self-consumption is the most natural in distributed virtual ECs, where the EC members self-consume generation from an off-site location.

D. Price arbitrage

In price arbitrage, the EC operator optimizes the consumption and storage of electricity according to the wholesale prices so that the EC minimizes consumption during expensive hours and maximizes self-consumption and usage of cheap hours. An EC platform operator can do the arbitrage with its energy storage when there are price differences between the wholesale price and the EC's local market [24]. In cases where EC members have time-of-use or dynamic rates, incentives exist also for the end-users. Price arbitrage can be done in some buildings through sector coupling by optimizing the usage of gas and district heating networks. Price arbitrage managed by an EC operator is, in principle, possible in all EC types. But if the end-users are engaged, they need a common tariff or another incentive for it. This applies especially to the EC types B and C, which happen behind-the-meter, and therefore customers share the same retail contract.

E. Local self-consumption

When self-consumption is done locally, it offsets usage of electricity from the public grid and external retailers and has an effect on the local grid. Several countries have implemented the REC regulation to function on the same public low-voltage distribution grid [5], [10]. If done within property boundaries, it also reduces the taxes and network tariffs paid. The self-consumption ratio can be increased by controlling or incentivizing flexible loads, such as heating water tanks or electric vehicle charging to hours with a lot of own production. Self-consumption can be fostered through different incentives and value sharing mechanisms [25]. Local self-consumption happens in different forms in all EC types, but the nature of self-consumption is very different in the distributed virtual EC. Therefore, it is categorized as another value stream. In that, the local grid conditions and tariffs are not considered and also, the RE production is not linked to local weather conditions.

F. Balancing, reserve and ancillary services

The EC operator aggregates EC resources for participation in demand response markets or balancing. This can be done by controlling heating or cooling machines for certain time periods. Naturally, the effects on the usual functions of the machines need to be considered. Having ECs participating in the ancillary service markets would increase supply in the market and therefore decrease prices. EC could also provide flexibility for retailers to balance the difference between the actual and the scheduled demand. These value streams are available for all EC types, but as they require a certain scale to enter the markets, they are more likely to be delivered by larger ECs and not single properties.

G. Peak shaving and reductions in power charges

Acquiring savings from reduced electricity distribution fees through demand charges offers one value stream also for ECs by controlling the loads so that the capacity limits are not exceeded. This also helps the DSO to postpone or reduce its possible grid reinforcement investments. In the case of EV chargers, lower peak power capacity also reduces the overall costs of the investment.

As this value stream is linked to the size of the DSO interconnection, it can be captured by single properties or private grids. Furthermore, as several countries are also linking the local virtual EC to a single low or medium-voltage grid, there is also an effect of supporting local demand management.

H. Avoiding outages

ECs have potential for ensuring security of supply during power outages by using energy storage and vehicle-to-home functionalities. DSOs could reduce their fees from disruptions by supporting these backup solutions. In a report by the Regulatory Assistance Project [26], also the possibility of ECs to participate in capacity markets is mentioned as one value stream. This value stream requires an energy storage solution, which is not usually the case in single properties. Although, battery costs are diminishing and vehicle-to-load and vehicle-to-home functions are getting more common, which can change the situation, especially in EC type B. In private grids and local virtual ECs, however, there can be enough resources and incentives to invest and operate energy storage.

I. Grid flexibility

With decentralized generation and demand response, ECs could provide grid flexibility services locally to solve grid congestion. This could postpone or reduce DSO's grid reinforcement investments, and one basic use case is a RE plant's grid connection. This value stream happens locationally and is most typical for the local virtual EC as it uses the local public grid. This value stream requires transparency from the DSO on where in its grid flexibility would solve the problems.[26]

V. Country Transpositions

There are some apparent differences in EU member state transpositions regarding different EC types. For example, countries that have adopted the local virtual EC type using the public grid are roughly centered in Southern and Western Europe (BE, PT, AT, IT, FR, ESP, NL, GR), whereas Nordics and Eastern European countries have at least for now transpositioned merely the EC types A and B based on the article on JARSC.

The non-EU members Switzerland and the UK have their models also for the EC type C, which contradicts with EU's principle of customer's freedom of choice. The Netherlands, Portugal and the UK have also formed regulatory sandboxes for different projects. Some can be categorized as ECs with their own grid and some as local virtual ECs experimenting, for example, p2p trading [27]. The implementation of the virtual distributed EC is less highlighted in the reviewed articles. Many countries have also transpositioned the directive texts directly to national legislation, which implies that especially the virtual distributed EC is covered, yet there are no significant steps taken to actually implement them.

VI. Discussion: Implications for EC development

In this chapter, we will discuss the implications of the diversity of EC types and value streams from a multi-level perspective: EC members, EC operators, and surrounding institutions.

A. *Energy community members*

ECs vary from simple models based on sole purchasing renewable energy (RE) to very sophisticated ones combining different value streams. The level of complexity affects the whole customer journey. A grassroots movement consisting of ordinary citizens will probably not engage in complex flexibility services, but relatively more simple value propositions, such as increased self-consumption or energy efficiency. For more complex models, there is a need for further assistance such as an operator or facilitator who connects different actors together and enables the EC service development [3].

The customer journey also depends on the locality. In local EC types, especially the A and B, all community members are somehow involved in the decision-making process. The EC directives support voluntary participation, yet, if an apartment building decides to invest in some RE technology, everybody is somehow affected by the decision. The voluntariness and independence of decision-making increases in virtual ECs, especially in the distributed virtual EC [28]. EC members' role in value creation is highlighted in ECs that aim for social value, e.g., feeling of togetherness, as well as environmental value. This can happen in any EC type, yet the customer's role in value creation is relatively lower in value streams like ancillary services or managing grid congestions that offer value for system operators and require a high level of automation. Value streams with a significant social element included, value creation may happen even between EC members. A p2p-market for virtual self-consumption is an example of such logic.

Multiple stakeholders can be seen as EC members as the value can be shared among different actors. However, they have different interests in EC creation [29]. Generally, the end-users are interested in economic and environmental benefits, system operators on the effects on the grid, and service providers on the scalability and profitability of the project. Financiers aim to lower the economic risks. Local governments may also aim at creating a living lab environment. Creating a common value proposition for the end-user needs to be developed with these differences in mind.

B. *Energy community operators*

The EC operator needs to consider the different interests and value propositions by positioning in a certain location in the energy value chain. Traditional electricity value chain could be divided into generation, distribution, and retail, but aside them, there are new elements in the chain: aggregator, digital platform provider, trading, flexibility options provider, consumption and contracting [3]. Different EC types have different activities shared among the partners delivering the value. Servitization requires collaboration from the EC providers and stakeholders. A commercialized customer-facing solution needs models where all stakeholders know their roles and processes. In EC type B and C, there is more clearly a service provider who is responsible for the whole EC, whereas in EC type A, D and E, the DSO, different retailers and the EC service provider are involved. One research [30] found that ECs behind-the meter were better able to differentiate themselves by offering services rather than kWhs as they had more control over the EC infrastructure and technologies. As there are limits and challenges to how big behind-the-meter systems can be, this remarks on the importance of collaboration in the EC design phase.

The value capture mechanisms, i.e., costs and revenues from various EC types differ remarkably. Typically, the costs are mostly up-front costs that consist of powerplant investments and related technologies. In behind-the-meter solutions, the EC also invests in smart meters and possibly the grid infrastructure. In virtual communities, the up-front investments can be smaller in relation to the customer basis. Yet, even if they use existing power production assets, also they include transaction and coordination costs in putting the EC in place and building the relevant data management platforms. The operational costs follow a similar logic, as all EC types include transaction costs, but in models behind-the-meter, the role of costs for maintenance and financing of physical assets is more important than in virtual ECs. Payments for using the public grid apply all EC types, yet behind-the-meter models can have savings in these relative to other models.

The revenue of ECs happens typically through savings in the energy bills, either by offsetting buying from a retailer or by saving in network tariffs (volumetric or capacity costs). Some can also earn from selling energy. Flexibility-oriented ECs can also earn revenue from ancillary and other markets through an aggregator. The operator has different options for revenue streams, ranging from asset sales to leasing agreements and subscription and brokerage fees [12]. These mechanisms may vary between the flexibility and production-based value streams. In the energy service company (ESCo) model, the operator earns by the brokerage fee, namely the difference between investment's financing costs and its energy selling price. A subscription fee can be combined also with operating p2p-markets or self-consumption schemes.

One question regarding the value capture is related to the value-sharing mechanisms and how they allocate the costs and benefits of EC's value delivery. A transition from current model to an EC should treat customers equally and fairly. Overall, the EC pricing mechanisms are crucial for their success. The energy crisis of 2022 forced many retailers to provide only spot price-contracts. An EC operator could work as a risk manager locally to protect EC members against price spikes. Even though there many elements to pricing, it needs to be simple enough for the customer to understand it well.

Data management and access require special attention from the EC operator. They are important in different steps of the EC lifecycle: feasibility studies and planning, operation, value sharing and allocation, optimization, and expanding the EC. The complexity of data management is caused by data quality, data security, complex regulations and a large number of stakeholders [13]. Different actors have different needs for data: aggregators need to know the availability of flexible loads and their impact on comfort levels, end-users want the energy consumption data visualized, and service providers managing the district-scale energy sharing want data on several buildings. [31] Operators using machine learning require large data sets for training the models. Furthermore, smart meters need to be in place, and interoperability between different automation systems needs to be ensured. Depending on the proximity of EC members, these data systems may include the neighborhood, building or home area networks [32]. Authors in [33] also argue for a new kind of openness and participatory processes in energy system planning.

Scalability of ECs is needed for EC operator business. Value streams based on investments to non-place-based production (type E) enable crowdfunding schemes and large participation volumes rapidly through an EC operator or platform.[11] Local self-consumption-based value streams require more configurational work [30] as they are coupled with on-site installations and the complexity of collective demand patterns. The digital tools, e.g. the value-sharing platforms, are scalable also for these value streams. The flexibility-based digital business models may scale relatively easily when customers already have flexible loads in their homes, although the assessments on the effects for user comfort and operations require extra effort. Also, complementing investments, such as home batteries and require heavy up-front investments and reconfiguring work [30]. Business models such as leasing can help to overcome these adoption barriers [34].

C. Institutions

Having an existing community makes the EC creation and decision-making easier. Regulations on EC types are typically based on national institutional differences. Housing associations and housing companies (EC types A and B), for example, form a natural context for bottom-up ECs and related decision-making. Such existing institutions can act also as intermediaries in several essential ways. First, they can help in transferring knowledge and learning. They also have their advocates and networks who have connections to policymakers who can help develop the regulation. These networks can also help gain resources, such as financing, for the ECs. Internally, the existing institutions also form an institutionalized conflict resolution mechanism. For new kinds of virtual ECs, there is a need for such intermediaries and networks.

However, having existing institutions like housing companies can also hinder the creation of arrangements that could be beneficial in the energy context. Also, if only EC types A and B are supported for the self-consumption value stream, this can incentivize the creation of large property boundaries. This can influence municipal-lead urban planning and real estate development. Changing or creating new institutional structures for EC accommodation requires institutional entrepreneurship, and sensing such requires strong embeddedness in the local context. EC types C and D would rely on such local institutions, but they are more likely to be born in a top-down or hybrid manner with a facilitator, such as a municipality. The EC type E is a non-place-based community-of-interest, which can diffuse despite local institutions, across the Internet, for example. Another aspect is the inclusion of sector coupling in the business model, which is easier in local ECs where energy flows are more closely tied together [33].

VII. Conclusions

Overall, the different EC types and the related value streams are linked to very different customer value propositions, require different capabilities from EC operators and other partners, and are linked and supported by different institutions. This paper provides a framework and state-of-the-art comparison of existing implementations in Europe. These results help EC project developers and regulators alike in positioning and analyzing EC projects.

Finally, it is unsurprising that the EC directive transposition has taken different directions in the EU member states. After all, energy policies and energy systems are very different, including varying degrees of market liberalization, the number of actors in the field, existing infrastructure, and the role and incentives for RE in the whole energy system. Moreover, as the diversity of EC-related value streams point out, there is manifold of regulations that affect the emergence of ECs, ranging from network tariffs to demand response markets.

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References

[1] EU, "Directive 2019/944 on Common rules for the internal market for electricity," *Official Journal of the European Union*, 2019.

[2] EU, "Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources," *Official Journal of the European Union*, pp. 82–209, 2018.

[3] J. Lowitzsch, K. Kreutzer, J. George, C. Croonenbroeck, and B. Breitschopf, "Development prospects for energy communities in the EU identifying best practice and future opportunities using a morphological approach," *Energy Policy*, vol. 174, p. 113414, Mar. 2023, doi: 10.1016/j.enpol.2022.113414.

[4] E. Neska and A. Kowalska-Pyzalska, "Conceptual design of energy market topologies for communities and their practical applications in EU: A comparison of three case studies," *Renewable and Sustainable Energy Reviews*, vol. 169, p. 112921, Nov. 2022, doi: 10.1016/j.rser.2022.112921.

[5] D. Frieden, A. Tuerk, C. Neumann, S. D'Herbemont, and J. Roberts, "Collective self-consumption and energy communities: Trends and challenges in the transposition of the EU framework," 2020.

[6] I. F. G. Reis, I. Gonçalves, M. A. R. Lopes, and C. Henggeler Antunes, "Business models for energy communities: A review of key issues and trends," *Renewable and Sustainable Energy Reviews*, vol. 144, p. 111013, 2021, doi: 10.1016/j.rser.2021.111013.

[7] D. Brown, S. Hall, and M. E. Davis, "Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK," *Energy Policy*, vol. 135, p. 110984, Dec. 2019, doi: 10.1016/j.enpol.2019.110984.

[8] R. Moura and M. C. Brito, "Prosumer aggregation policies, country experience and business models," *Energy Policy*, vol. 132, pp. 820–830, 2019, doi: 10.1016/j.enpol.2019.06.053.

[9] S. Hall, D. Brown, M. Davis, M. Ehrtmann, and L. Holstenkamp, “Business Models for Prosumers in Europe,” PROSEU - Prosumers for the Energy Union: Mainstreaming active participation of citizens in the energy transition, 2020.

[10] G. Iazzolino, N. Sorrentino, D. Menniti, A. Pinnarelli, M. De Carolis, and L. Mendicino, “Energy communities and key features emerged from business models review,” *Energy Policy*, vol. 165, p. 112929, Jun. 2022, doi: 10.1016/j.enpol.2022.112929.

[11] M. Kubli and S. Puranik, “A typology of business models for energy communities: Current and emerging design options,” *Renewable and Sustainable Energy Reviews*, vol. 176, p. 113165, Apr. 2023, doi: 10.1016/j.rser.2023.113165.

[12] S. P. Burger and M. Luke, “Business models for distributed energy resources: A review and empirical analysis,” *Energy Policy*, vol. 109, no. July, pp. 230–248, 2017, doi: 10.1016/j.enpol.2017.07.007.

[13] L. Babilon, M. Battaglia, M. Robers, M. Degel, and K. Ludwig, “Energy communities: Accelerators of the decentralised energy transition.” Deutsche Energie-Agentur, 2022.

[14] M. Krug *et al.*, “COME RES Deliverable 7.1 Comparative assessment of enabling frameworks for RECs and support scheme designs.” 2022.

[15] J. Valta *et al.*, “Towards practical typology of energy communities: main differentiating elements and examples of promising implementations.” CIRED 2021, 2021.

[16] M. Stadler *et al.*, “Value streams in microgrids: A literature review,” *Applied Energy*, vol. 162, pp. 980–989, 2016, doi: 10.1016/j.apenergy.2015.10.081.

[17] M. B. Roberts, A. Bruce, and I. MacGill, “A comparison of arrangements for increasing self-consumption and maximising the value of distributed photovoltaics on apartment buildings,” *Solar Energy*, vol. 193, no. July, pp. 372–386, 2019, doi: 10.1016/j.solener.2019.09.067.

[18] CEER, “Regulatory Aspects of Self-Consumption and Energy Communities,” Brussels, 2019. [Online]. Available: https://www.ceer.eu/documents/104400/6509669/C18-CRM9_DS7-05-03_Report+on+Regulatory+Aspects+of+Self-Consumption+and+Energy+Communities_final/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a?version=1.1

[19] Eurelectric, “Citizens Energy Communities: Recommendations for a successful contribution to decarbonisation,” 2019.

[20] A.-L. Vernay, C. Sebi, and F. Arroyo, “Energy community business models and their impact on the energy transition: Lessons learnt from France,” *Energy Policy*, vol. 175, p. 113473, Apr. 2023, doi: 10.1016/j.enpol.2023.113473.

[21] Department of Energy & Climate Change, “Collective Purchasing and Switching: What consumers need to know.” 2013. [Online]. Available: https://www.gov.uk/guidance/collective-switching-and-purchasing

[22] H. Hampton, A. Foley, D. F. Del Rio, B. Smyth, D. Laverty, and B. Caulfield, “Customer engagement strategies in retail electricity markets: A comprehensive and comparative review,” *Energy Research & Social Science*, vol. 90, p. 102611, Aug. 2022, doi: 10.1016/j.erss.2022.102611.

[23] T. Pahkala, H. Uimonen, and V. Väre, “Flexible and customer-centred electricity system - Final report of the Smart Grid Working Group,” Publications of the Ministry of Economic Affairs and Employment, Helsinki, 2018.

[24] J. M. Schwidtal *et al.*, “Emerging Business Models in Local Energy Markets: A Systematic Review of Peer-To-Peer, Community Self-Consumption, and Transactive Energy Models,” 2022. [Online]. Available: http://dx.doi.org/10.2139/ssrn.4032760

[25] A. Kulmala, M. Baranauskas, A. Safdarian, J. Valta, P. Järventausta, and T. Björkqvist, “Comparing Value Sharing Methods for Different Types of Energy Communities,” in *ISGT Europe*, Helsinki: IEEE, 2021, p. 6.

[26] B. Claeys, “Energy communities with grid benefits,” Regulatory Assistance Project, Brussels, 2021. [Online]. Available: https://www.raponline.org/knowledge-center/energy-communities-with-grid-benefits-a-quest-for-a-blueprint/

[27] CEER, “Dynamic NRAs to Boost Innovation - Report on NRAs’ experiences and recommendations on Dynamic Regulation.” 2022.

[28] E. M. Gui and I. MacGill, “Typology of future clean energy communities: An exploratory structure, opportunities, and challenges,” *Energy Research and Social Science*, vol. 35, pp. 94–107, 2017, doi: 10.1016/j.erss.2017.10.019.

[29] S. Heuninckx, C. Macharis, and T. Coosemans, “Stakeholder objectives for joining an energy community: Flemish case studies,” *Energy Policy*, vol. 162, p. 112808, 2022, doi: 10.1016/j.enpol.2022.112808.

[30] J. Barnes, P. Hansen, T. Kamin, U. Golob, M. Musolino, and A. Nicita, “Energy communities as demand-side innovators? Assessing the potential of European cases to reduce demand and foster flexibility,” *Energy Research & Social Science*, vol. 93, p. 102848, Nov. 2022, doi: 10.1016/j.erss.2022.102848.

[31] A. Tuerk *et al.*, “Integrating Plus Energy Buildings and Districts with the EU Energy Community Framework: Regulatory Opportunities, Barriers and Technological Solutions,” *Buildings*, vol. 11, no. 10, p. 468, Oct. 2021, doi: 10.3390/buildings11100468.

[32] V. Z. Gjorgievski, S. Cundeva, and G. E. Georghiou, “Social arrangements, technical designs and impacts of energy communities: A review,” *Renewable Energy*, vol. 169, pp. 1138–1156, May 2021, doi: 10.1016/j.renene.2021.01.078.

[33] C. E. Hoicka, J. Lowitzsch, M. C. Brisbois, A. Kumar, and L. Ramirez Camargo, “Implementing a just renewable energy transition: Policy advice for transposing the new European rules for renewable energy communities,” *Energy Policy*, vol. 156, 2021, doi: 10.1016/j.enpol.2021.112435.

[34] M. Kubli and P. Canzi, “Business strategies for flexibility aggregators to steer clear of being ‘too small to bid,’” *Renewable and Sustainable Energy Reviews*, vol. 143, p. 110908, Jun. 2021, doi: 10.1016/j.rser.2021.110908.

TABLE 1 VALUE STREAMS IN EC TYPES AND COUNTRY IMPLEMENTATIONS. X=TYPICAL VALUE STREAM, (X)= POSSIBLE BUT NOT TYPICAL VALUE STREAM, “-” = NOT POSSIBLE VALUE STREAM)

Type	**Front-of-the-meter EC within one property**	**Behind-the-meter EC within one property**	**Own grid**	**Local virtual EC**	**Distributed virtual EC**
Directive	JARC	JARC	CEC	REC, CEC	CEC
Country examples	FI: Hyvityslaskenta AT: EIWOG DE: Mieterstrom IT: Decree-Law 318/2020	FI: Takamittarointi	CH: ZEV UK: Private wire PT: CECs as CDNs	FR: Autocons. collective NL: Postcoderoos IT: Decree-Law 8/2020 ESP: Royal Decree 244/19 PT: Decreto-Lei 162/2019 BE: different models PO: Energy cluster PT: DL 15/2022 AT: Erneuerbare Energiegemeinschaften	AT: Bürgerenergiegemeinschaften DE: Bürgerenergiegesellschaft
A. Collective electricity purchasing	(X)	X	X	(X)	(X)
B. Selling collectively owned production	(X)	(X)	(X)	(X)	X
C. Distributed self-consumption	(X)	(X)	(X)	(X)	X
D. Price arbitrage	(X)	X	X	(X)	(X)
E. Local self-consumption	X	X	X	X	(X)
F. Balancing, reserve, and ancillary services	(X)	(X)	X	X	X
G. Peak shaving and reductions in power charges	(X)	X	X	(X)	-
H. Avoiding outages	-	(X)	X	X	-
I. Grid flexibility	-	(X)	X	X	-

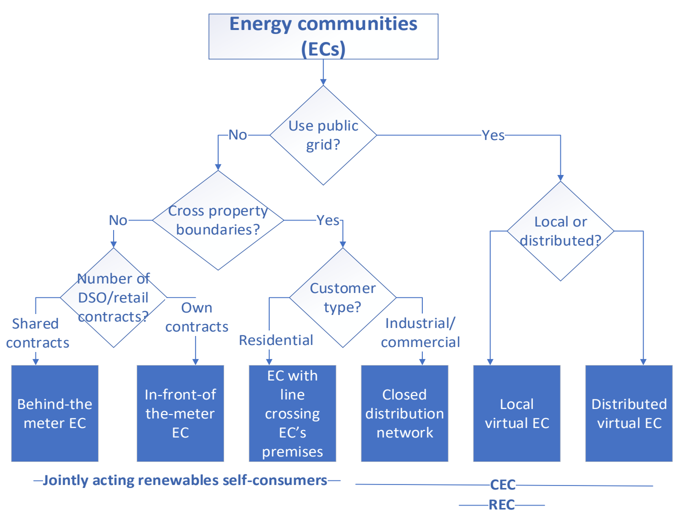

Figure 1. Decision-tree for EC typology used in the study [15]