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Review

Reviewing and Exploring the Qualitative Impacts That Different Market and Regulatory Measures Can Have on Encouraging Energy Communities Based on Their Organizational Structure

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Abstract: The emergence of energy communities represents a promising option to democratize the energy system by empowering consumers to take a more active role. This can aid in achieving energy and environmental goals as well as encouraging more equitable distribution of costs and revenues between all parties on the energy system. Despite this potential, energy communities are still a nascent solution, the success of which is heavily influenced by regulations. As a result, there are a wide variety of organizational structures for energy communities at this time. This paper provides a review of the policy landscape in Spain as it relates to energy communities. This work also presents a formalized method for characterizing different energy community structures and provides a qualitative assessment of the impacts of different measures to encourage energy communities with respect to their organizational structure. Findings suggest that many market-focused measures, including wholesale, local flexibility, capacity, and multisector market measures favor larger, more integrated communities, while regulatory, legal, and organizational measures, including peer-to-peer trading, aggregation, and self-consumption favor smaller, more distributed communities. Additionally, when developing policies to encourage the growth of energy communities, policymakers should be cognizant of the progression of policies in the context of the desired outcomes for energy community growth specific to the region or country and its goals.

Keywords: energy community; citizen energy community; renewable energy community; market measures; regulatory measures; organizational structure; implementation strategies; implementation measures; policymakers

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1. Introduction

The energy system in Europe is going through a transition with the goal to reduce energy consumption, increase efficiency, and increase renewable shares [1]. This transition will occur over the next several decades, with key targets in 2025, 2030, and 2050 [2–4]. The measures being taken to achieve these goals are starting to have important effects on the energy system. The European Commission is guiding the Member States through the directives of the Clean Energy for All Europeans Package (CEP) [5], which includes aspects regarding energy transition and new energy market design [6]. In this package, the Commission has chosen to give an important role to citizens, and most of the directives aim to increase consumer participation in the energy system [1,7]. In order to do so, the concept of energy communities (ECs) has been gaining momentum as a vehicle to foster energy transition and citizen participation [8].

The European directives contain the definition of two types of ECs, Renewable Energy Communities (RECs) defined in the Renewable Energy Directive 2018/2001 [9] and Citizen Energy Communities (CECs) defined in the Market or Electricity Directive 2019/944 [10]. These concepts have some similarities, for instance, they both involve open and inclusive citizen participation, and they focus on social and environmental outcomes more than on economic profits [11]. The main differences are related to membership rules, allowed activities, geographic scope, and allowable generation technologies. Specifically, the CEC is devoted to electricity (no other energy sources are included in the definition), while RECs can only include renewable technologies but can include energy sources different from electricity (e.g., heat). Similarly, REC members need to be located near the area where the outcomes have their effect, while for CECs, there are no significant restrictions on the geographical location of the members [12]. The definitions of ECs that appear in the European directives and in the literature are functional definitions. They put the focus on what communities can do, on the activities they can perform, more than on the requirements they should meet to be considered an EC [12,13]. Additionally, the rules are quite open. Reducing restrictions encourages greater participation and potentially greater innovation. In this study, we will also follow this approach.

While ECs are seen as a vehicle for the energy transition, transitions do not occur in a vacuum, and both require and are affected by a variety of interrelated aspects. This is particularly relevant for energy communities that require technology, economic resources, and social and institutional support [14,15]. Efforts have been made at the European level, and for the many Member States on the institutional side, to prepare for energy communities, as evidenced by the evolution of legislative frameworks [16]. This paper provides extensive discussion about the legislative framework established for energy communities in Spain and throughout Europe.

Several of the technical challenges related to the increase in shares of renewables in the system might be solved if ECs are properly developed [12,17]. As an example, ECs can contribute to the increased share of renewable generation, self-sufficiency, and flexibility of energy assets which could lead to a variety of benefits, including environmental (lower emissions), social (more equitable distribution of benefits), and economic (lower consumer costs, lower system costs, and delayed grid expansion) [18–21]. Flexibility in energy systems generally allows for a more effective response to accommodate changes in demand and production and to manage other issues in the network [22,23]. It is a concept that has gained momentum in the literature during recent years because it is seen as an important aspect in the context of the energy transition, where renewable energy generation, and in particular distributed generation, will play a key role. Transmission and distribution systems will also face new challenges to ensure the reliability of supply [22,24–26]. Moreover, if flexibility mechanisms are not properly developed, increasing the renewable share of the energy sector will be difficult and potentially costly [4]. Hence, ECs can be seen as a positive tool to support renewable generation because they represent a way of increasing flexibility and reliability of the system, solving some of the issues that come with increased shares of renewable generation.

Furthermore, ECs can contribute to fostering other aspects of the energy transition, including the development of Combined Heat and Power systems (CHP) or the increase of electric mobility and electric vehicles (EV) [1,11,27]. Reciprocally, the proper development of CHP systems and EVs may have positive impacts on the growth of ECs. Thus, the development of ECs can bring both technical and economic benefits. Additionally, the European directives and the abovementioned definitions for communities also discuss the benefit from social outcomes in the local community. Increasing consumer participation in the energy system is a way of empowering citizens if it is appropriately achieved [28] and can result in the more equitable distribution of benefits amongst the participants in the energy system with the potential to help those in energy poverty [17,29]. Hewitt et al. found that energy community initiatives developed around the 2008 financial crisis more strongly focused on this type of energy democratization, while recent energy community initiatives are more diverse and address “virtually all aspects of energy” [8].

One of the consequences of the energy transition is that traditional roles of the energy system and how entities in these roles can interact with each other need to be revised [6,30]. Moreover, the CEP (2019) includes some new roles that need to be taken into consideration in a smart and decarbonized system, including the role of independent aggregators [24]. The traditional paradigm of unidirectional energy flow from generation to end-consumers through transmission and distribution networks has evolved to a smart system with distributed resources and a bidirectional flow of energy and services [11,22]. Additionally, less centralized and more distributed growth in the energy sector can provide a fertile ground for a more sustainable transition. The literature related to sustainable transitions recognizes the importance of proximity, both spatial and nonspatial, in better understanding the impact of changes in the energy sector [31,32]. ECs can have locational proximity requirements, specifically RECs, and important nonspatial requirements, including organizational, social, and institutional, that play a significant role in the formation and success of ECs [1].

While there is a lot of potential for encouraging active consumer participation in the energy system, this participation does not come without challenges. They include organizational issues, planning issues, lack of resources, including financial resources and appropriate market incentives, lack of or limited institutional support, operation of the EC and operation of the grid, as well as existing regulatory environment [1,13]. Before pursuing any specific measure, it is helpful to evaluate the scope and expected outcomes for each measure, including from legal, economic, social, organizational, technical, and market design perspectives [33]. Changes in the legislative framework are needed to allow interaction between participants and to enable and encourage the growth of ECs [1,6]. Additionally, as part of the European PROSEU project, Horstink et al. found that ECs and other initiatives related to citizen participation and renewable energy are developing faster than the policy frameworks which should sustain them [34]. In order to address this issue, Horstink et al. focus on the organization of Community Energy initiatives and suggest policies based on a proposed categorization. The present article utilizes a similar approach—the measures suggested are based on an analysis of the roles that ECs can perform more than on their internal organizational structure and their motivations.

These challenges are being faced by the Member States during the process of transposition of the European directives of the CEP into national laws. The European directives include suggestions and general ideas, but they do not specify what should be the proper legal framework for ECs [1]. Identifying this framework is a task for researchers and policymakers. The process of transposition should have finished by June 2021, but most of the member states will need more time [1,35]. Due to socioeconomic differences and previous legal differences between the Member States, the speed of implementation is different for every country [13].

This paper gathers findings, recommendations, and important frameworks from academic literature and previous and ongoing European projects. Many of the reviewed resources identify the barriers or challenges to energy community growth in great depth but provide limited commentary on the relative impacts of addressing those barriers, particularly within the context of EC roles and implementation strategies. The goal of this paper is to address, in part, the question of “what kind of energy communities do we want to have in the future” (e.g., more local or more regional, more integrated or more isolated, a larger role for distributed entities or a smaller role), and how our decisions to address the identified barriers for EC growth affect this outcome.

The goal of this paper is first to review the status of regulations related to ECs in Spain. Leveraging the frameworks established in the literature and through European projects, the next step is to articulate specifications for the current roles in the energy system. Then we explore how ECs can fit into the specified roles, resulting in a set of organizational strategies for ECs to interact with other entities in the energy system. Finally, we develop a set of implementation measures that include a variety of methods for encouraging the growth of ECs, including legal, economic, social, organizational, technical, and market-based measures. The qualitative impact of these measures will be compared across EC organizational strategies to ascertain themes and to help guide researchers and policymakers when making decisions about the best ways to encourage ECs based on their particular goals and desired outcomes.

2. Methodology

This report relies on the review and analysis of the existing literature. The references used include research, reviews, and technical reports, along with project deliverable reports, EU Directives, and Spanish legislation. The academic references that have been included cover different topics: definition and features of ECs, barriers and drivers of ECs, legal aspects of Community Energy and European directives, market aspects, and social considerations. The selection of the sources has been made with the intention of approaching the issues from a variety of perspectives. While Spain is the main case study for this paper, it is important to maintain perspectives from experience across Europe, which is why this paper includes articles and studies focused on Europe as well.

Using these references, we conceptualized Spain's energy community ecosystem with the methodological approach depicted in Figure 1. The Figure articulates the roles of relevant entities and identifies which roles ECs can assume. Finally, a set of strategies to aid EC implementation developed and compared across the potential EC structures to identify the qualitative impacts of introducing different implementation strategies.

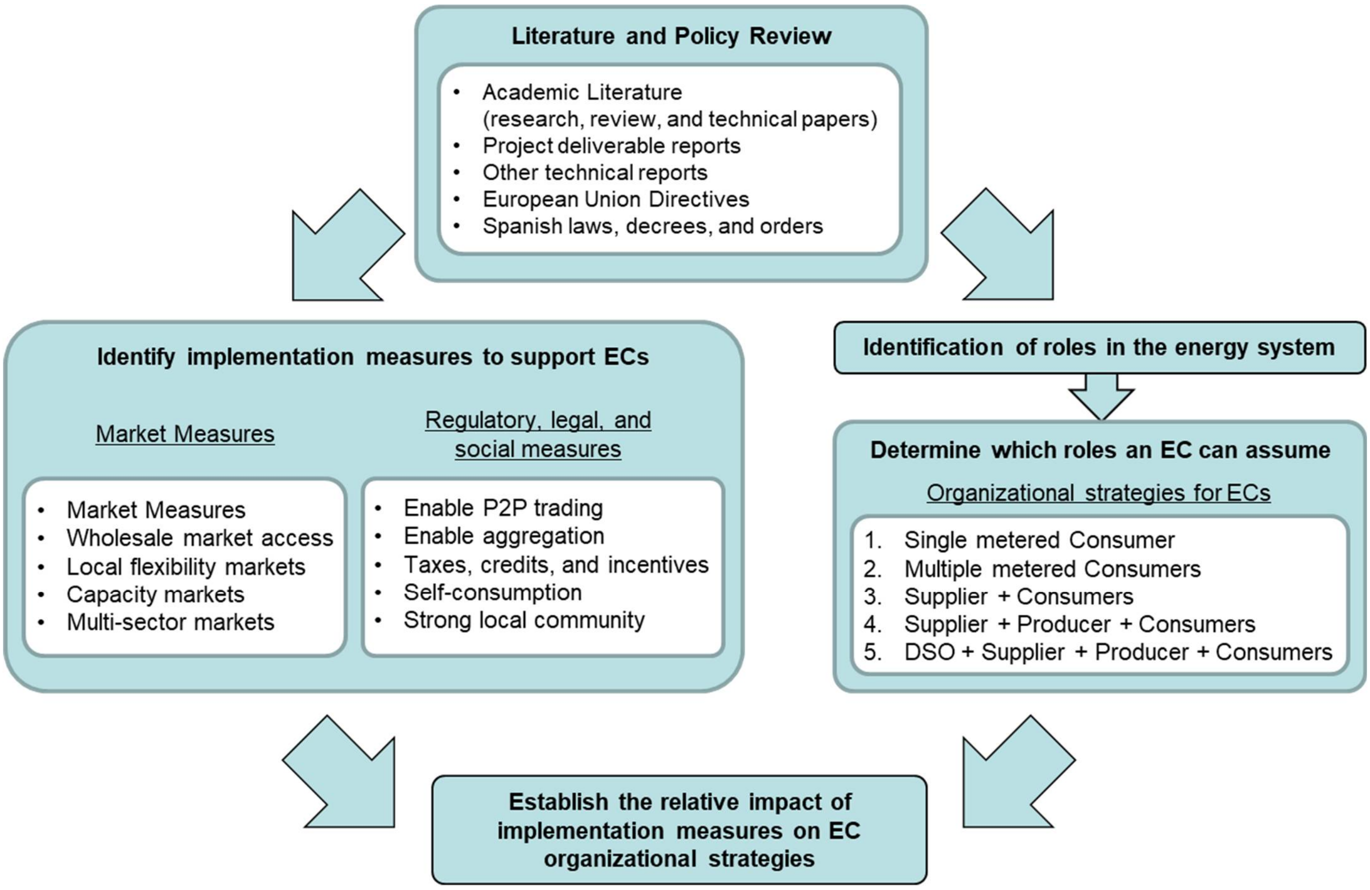

Figure 1. Overview of the selected approach for assessing EC organizational strategies.

3. Review of Regulatory Environment for Energy Communities in Spain

The realization of Spain's climate and energy goals has resulted in new policies and regulations. Many of these evolved from European directives, and in the particular case of ECs, the most relevant regulations and directives have been included in the CEP, which was completed in 2019 and includes four regulations and four directives [5]. Generally, this package focuses on energy efficiency, building performance, renewable energy, climate actions, internal electricity markets, and energy regulators. This section presents a summary of Spain's plans and legislations relevant to energy communities. On account of societal, political, and economic differences as well as existing differences in legislation, the rhythm of implementation is quite different between the Member States [13].

In 2019, Spain developed a tool development guide to foster local ECs [36]. This guide considers the challenges and barriers to implementing ECs and covers the legal, economic, social, and technical aspects.

At present, the status of regulations regarding ECs in Spain largely follows the proposals made in the National Integrated Energy and Climate Plan (NECP) on 20 January 2020 [4]. The NECP presents challenges and opportunities for Spain in five aspects: decarbonization (renewable energies), energy efficiency, energy security, energy market, and investigation & creativity. Since this plan is a first step towards addressing European directives, including the CEP and "A clean planet for all" [37], the discussion of empowering citizens and ECs is woven throughout the document.

Following the publication of the NECP, the government adopted an initial law, Real Decreto-ley 23/2020 on 23 June 2020, which included what can be considered the first legal definition of renewable energy communities in the Spanish legal system, together with some measures to enhance the energy transition and energy efficiency [38]. It is worth noting that citizen energy communities were not included in this definition [39]. This law also addresses aggregation and the figure of an independent aggregator. In line with European Directives, independent aggregators are entities that provide aggregation services but are not related to the supplier of the consumers which they are aggregating—a distinction that will be discussed in more detail later. The remuneration framework for generated energy from renewable sources was further developed with the passage of Real Decreto 960/2020 [40] on 4 November 2020.

In addition to the NECP, to aid in the recovery process from the COVID-19 pandemic, Spain developed a recovery, transformation, and resilience plan [41] in October 2020, which was enacted on 30 December 2020 with Real Decreto-ley 36/2020. Spain also developed a long-term decarbonization strategy for 2050 [42] which was released in November 2020. Both of these plans include a discussion about the role of the citizen in the energy sector, and the former discusses activities that should be pursued or are already being pursued.

In May 2021, Ley 7/2021 on climate change and energy transition was passed [43]. This law includes measures to support groups and workers vulnerable to the consequences of the energy transition. Also, within a year of its passage, a proposal must be developed to reform the electricity sector with a focus on consumer participation in energy markets through aggregation, energy storage, and local energy markets. This has the potential to expand and improve available markets and business cases for ECs.

There have also been two public consultations in Spain specifically related to ECs. The first was in November 2020 with the purpose of identifying the concerns of the interested parties and the main challenges that need to be overcome related to ECs [44]. In February 2021, the Spanish government organized another public consultation related to ECs [45]. The second consultation was focused on identifying projects, initiatives, and research lines in the field of ECs. This will aid the government in understanding the appropriate technical parameters, financing, and other support mechanisms that govern the evaluation of projects for potential future funding opportunities.

As of March 2021, the Lightness project, a European project funded through the H2020 program, found that there are 33 ECs in Spain [33]. It is challenging to count the number of active ECs, as the results vary based on the EC definition used, and information about communities can be difficult to find [46]. Establishing energy cooperatives is the main EC model. Some of these cooperatives have a very long history. These communities are usually local initiatives promoted by citizens, often with the primary motivations being social rather than economic. Many of these communities take advantage of regulations governing self-consumption, collective self-consumption, and distributed generation. This enables them to generate revenue for surplus generation of distributed renewable generation and, in some cases, exchange energy amongst the community members, thereby increasing the consumption of renewable generation and reducing their electricity bills. Real Decreto-ley 15/2018 was passed on 5 October 2018 and regulates consumer protections, self-consumption, and actions aimed at accelerating the energy transition to a decarbonized economy [47]. This law was followed by Real Decreto 244/2019 on 5 April 2019 to provide more complete guidance on self-consumption [48]. Real Decreto 244/2019 enacts several conditions and constraints related to self-consumption, including (1) that the connection between the entities that want to share energy should either be connected with a direct line connection or connected on the same low voltage network, (2) the consuming entity must be at most 500 m from the production facility, and (3) simplifications with respect to registration, and contracting as well as enabling new compensation mechanisms for systems less than 100 kW, though self-consumption facilities can be greater than 100 kW. In June of 2021, Real Decreto 477/2021 was released, which implements new incentive programs for self-consumption and storage. On 21 December 2021, Real Decreto 29/2021 was passed [49]. This legislation relaxes the requirement that self-consumption occur only on low voltage systems, allowing community members to be connected to high voltage systems as well. It also mentions the 500 m limitation between producing and consuming entities and clarifies the process for measurement. While there have been some recommendations about removing the 500 m limit [39], no adjustments have yet been made to this constraint. One concern from those participating in collective self-consumption was that allocating the generated energy to interested consumers was complicated by the fact that the collective self-consumption agreement had a static distribution coefficient. This means that any energy generated by the producer would be proportionally distributed at the same ratio for every hour of the day. This limited the effectiveness of collective self-consumption, so the implementation of a dynamic distribution coefficient that could be modified for each hour was made law with Order TED/1247/2021 [50].

As a reference, Table 1 provides a relationship between relevant EU directives and Spanish legislation, highlighting the transposition process of EU directives in Spain.

Table 1. Summary of the relationship between Spanish laws and EU directives.

Spanish Laws	European Directives
Real Decreto 244/2019	2018/2001 (renewable energy)
NECP, 2020	COM (2016) 860, COM (2018) 773 (A clean planet for all), and several directives from the CEP: 2018/2001 (renewable energy), 2018/2002 (energy efficiency), 2019/944 (electricity directive).
Real Decreto-ley 23/2020	2019/944 (electricity directive), 2018/2001 (Renewable energy), and 2018/2002 (Energy efficiency). All of them are part of the CEP.
Real Decreto 960/2020	2018/2001 (Renewable energy) and 2019/944 (electricity directive)
Real Decreto 477/2021	2018/2001 (renewable energy) with references to 2019/944 (electricity directive)

4. Comparison of the Structure of Communities with Strategies to Encourage Growth

To better understand the conditions that can encourage the growth of energy communities, this section is separated into four subsections. First, general specifications for the roles within the energy system are presented. Next, a description of the methods and structures for interaction between the community and the larger grid is established. Then, a list of options for encouraging the growth and implementation of ECs is presented. Finally, comparisons are drawn between community organizational structures and implementation options to provide a qualitative understanding of the types of community structures that will be encouraged, given different sets of implementation measures (e.g., market, regulatory, legal, social, etc.)

4.1. Roles in the Energy System

Within the energy system, there are specific roles that have developed. The extent of the roles and the terminology that defines them have developed gradually, as different regions and Member States try various strategies and share their best practices. Within Spain, the scope for most of the following roles is clearly defined in regulation. A general framework for functions and interactions of the roles has been developed by the Universal Smart Energy Foundation (USEF) [30]. A given entity can serve multiple roles, a concept that will be further explored in the next section.

List of key roles, including a brief description and comments:

1. Consumer: Any entity that has electrical loads. They can buy electricity from a supplier or generate it themselves (also known as active consumers or prosumers). Apart from generation, consumers can own storage, flexible loads, home control mechanisms, etc. They can provide implicit flexibility (related to managing peak consumption, time of use rates, and network tariffs) or explicit flexibility, acting as a flexibility service provider to sell flexibility services to flexibility-requesting parties. There are different types of consumers with different needs and resources: residential vs. nonresidential, urban vs. rural [6,51];
2. Regulator: This role is performed only by government organizations and policymakers of the associated member states. These governments are influenced by the European Commission and its directives but also by the social, geographical, political, and economic context of each country [8]. The energy transition is a largely political process, so the role of regulators is very important [28]. Regulators establish laws, norms, and rules and have the power to incentivize (or not) different initiatives;
3. Transmission System Operator (TSO): TSOs own and operate high-voltage electricity transmission networks. TSOs must maintain short-term system reliability, for example, by maintaining voltage and frequency within the required limits and solving outage issues related to their infrastructure, as well as long-term system reliability through the long-term planning of infrastructure and generation and load resource forecasting. This role is a natural monopoly and is thus served by one entity in each region [7];
4. Supplier: Suppliers enter contracts with consumers to provide them energy at an agreed-upon rate and send electricity bills according to that rate. In order to do this, suppliers need to have an agreement with producers or be producers themselves.
5. Producer or energy generator: This role includes any participant of the energy system who is able to produce electricity. Apart from the traditional power plants (nuclear, thermal, hydroelectric), this role includes distributed generation and self-consumption (photovoltaic (PV) in residential buildings, wind power, etc.). Producers must be able to inject electricity into the grid, but they are not obliged to do so;
6. Distribution System Operator (DSO): DSOs own and operate distribution networks (medium voltage (MV) and low voltage (LV) electricity networks). Their responsibilities are similar to those of TSOs: ensure the electrical supply quality, troubleshoot issues, maintain equipment, and measure electricity consumption [22,52];
7. Balancing Service Provider (BSP): BSPs provide various services to the TSOs by participating in balancing markets or through bilateral contracts. These services include frequency containment reserve and frequency restoration reserve;
8. Balancing Responsible Party (BRP): Each market participant is responsible for the imbalances it causes in the energy system. Regulations in Spain include this responsibility; see, for example, Real Decreto 244/2019 on self-consumption [48]. This responsibility is assigned to a BRP, which can be a third party or another market participant;

9. Flexibility Service Provider (FSP): FSPs provides flexibility services (usually "explicit" flexibility services, like voltage control, congestion management, capacity requirements, etc.) to the Flexibility Requesting Party (FRP), which might be a DSO (most common case), a TSO, or a BRP [30].

4.2. Energy Community Organizational Strategies

Energy communities can assume a variety of the roles defined in the previous section. Five unique EC organizational Strategies are constructed from a combination of the previously presented roles. This effectively takes a functional view of ECs, defining them by their activities rather than their motivations. It is noted in the European Union (EU) Directive 944/2019 that CECs can assume the roles of final consumers, producers, suppliers, or distribution system operators. Similarly, Article 22 of the EU Directive 2018/2001 establishes that there shall be no discriminatory treatment of RECs as it relates to their activities, which means that both CECs and RECs can act as consumers, producers, suppliers, or distributions system operators.

List of proposed organizational strategies to form ECs and a brief description:

1. Single-metered consumer (Strategy 1). Depending on the definition, a single consumer might not be considered an EC since there is no broader community [13]; however, for this assessment, a single-metered consumer can include an individual consumer or a collection of consumers under one meter. This can include a microgrid, which is a decentralized set of generation, loads, and storage assets connected to the grid, with the ability to disconnect and operate in an islanded configuration. The European Directives of the CEP aim to foster individual participation. Each citizen has to be able, to some degree, to decide and participate in the energy system [5]. Based on the minimum entry requirements for wholesale markets and the lack of local flexibility markets or direct markets between consumers (e.g., peer-to-peer (P2P) markets) in Spain, a single consumer (except for large commercial and industrial consumers who have sufficient size) have limited options for wholesale market participation and instead must rely on reducing their utility bill costs by optimizing their consumption through the use of flexible loads, storage, EVs, heat pumps, and other control mechanisms. A recent example is the Schneider Electric Puente la Reina microgrid, which includes the production of renewable energy on-site, battery storage, and charging points for electric vehicles;
2. Multiple-metered consumers (Strategy 2). This involves a collection of consumers organized to form a community. As will be discussed in greater detail later in this section, consumers can take on a variety of connection strategies, including connection of all consumers to a single meter, as in a microgrid, connected to different meters on the same electrical substation, or connected to different meters on different substations or even taking service under different DSOs. The type of connection and geographical relationship defines the types of interactions amongst consumers and with the DSO. For instance, a consumer is able to share energy freely with other consumers if all consumers are behind a single meter, for consumers behind different meters, there are regulatory limitations and additional costs to share energy, lastly, for communities that have consumers that span multiple DSOs, there are additional regulatory and cost hurdles. The communities can own different types of flexible loads (EV, heat pumps) and storage systems which may also help to improve the performance of the community (regarding consumption). This organizational strategy includes generation that follows the rules for self-consumption but does not include large-scale generation intended for export. This community typically cannot sell energy into wholesale markets, but they might be able to sell it to neighbors through P2P or local markets, directly or through an independent aggregator. An example of an entity utilizing this strategy is Sapiens Energía which helps establish energy communities that can take advantage of the Spanish collective self-consumption laws;

3. Supplier + Consumers (Strategy 3). This strategy expands on Strategy 2 to include the role of an energy supplier. The community takes responsibility for establishing electricity rates and billing. They work directly with the DSO and generators to acquire the needed electricity while also meeting the social, environmental, or financial goals of the community. The supplier can also act as a community manager, providing control and optimization, just as in Strategy 2. With optimization of the site and the potential to include additional flexible loads and storage, the consumption performance and savings of the community may improve; however, not as good as with the addition of generation services, as presented in strategy 4 [51]. Examples of entities using this strategy include Megara Energía and the cooperative Energy plus people (E + P);
4. Supplier + Producer + Consumers (Strategy 4). This strategy is similar to Strategy 3 but includes generation assets, which increases the possibilities of optimization and flexibility and is quite common in the technical papers on microgrid modeling [51,53–55]. This community model can include collective ownership of generation and storage systems beyond the scope considered for collective self-consumption and include but is not limited to distributed or large-scale generation, storage systems, heat pumps, combined heat and power, district heating, and EVs. The community itself can manage its demand and generation and trade energy through bilateral contracts or participate in wholesale markets or any available local markets (e.g., capacity, congestion, balancing), or this can be accomplished by contracting an independent aggregator [22,30]. SOM Energía and goiner are two examples of entities using this strategy;
5. DSO + Supplier + Producer + Consumers (Strategy 5). This organizational strategy adds the role of DSO to Strategy 4. Following the liberalization of the energy system, the DSO remains a regulated entity, while suppliers, generation, and consumers are separate and still have regulations they must follow, but they also have access to deregulated markets. Taking on the role of the DSO requires a significant increase in responsibility, moving from just the acquisition of electricity and billing to including distribution system planning, operation, and maintenance to secure the supply of electricity for consumers. Despite this boundary, the possibility of ECs becoming DSOs presents some interesting opportunities, particularly with respect to the formation and allowance of local and P2P markets, distribution rate setting, and rules and guidelines for energy community development. A few examples of entities using this Strategy include Endesa, Enercoop, and Grup Cuerva.

Each of the EC organizational strategies has multiple ways in which it can be implemented, depending on the geographic locations of community members and the corresponding regulations. Figure 2 depicts four of these. EC1 represents a single-metered connection which could be a single consumer or a collection of consumers. EC2 represents a community with multiple-metered connections all on the same distribution circuit. EC3 represents multiple consumers distributed across distribution circuits, but all served by the same DSO. EC4 represents a collection of consumers distributed across distribution circuits and DSOs.

To provide some context to the situation in Spain, current legislation allows for EC1 and EC2, but since EC3 and EC4 span different distribution networks, they are not included. This is not necessarily a bad decision as there are reasons to encourage collective self-consumption consumers to stay connected to the same network (served by the same distribution transformer) and is only pointed out to provide an example for the Spanish system.

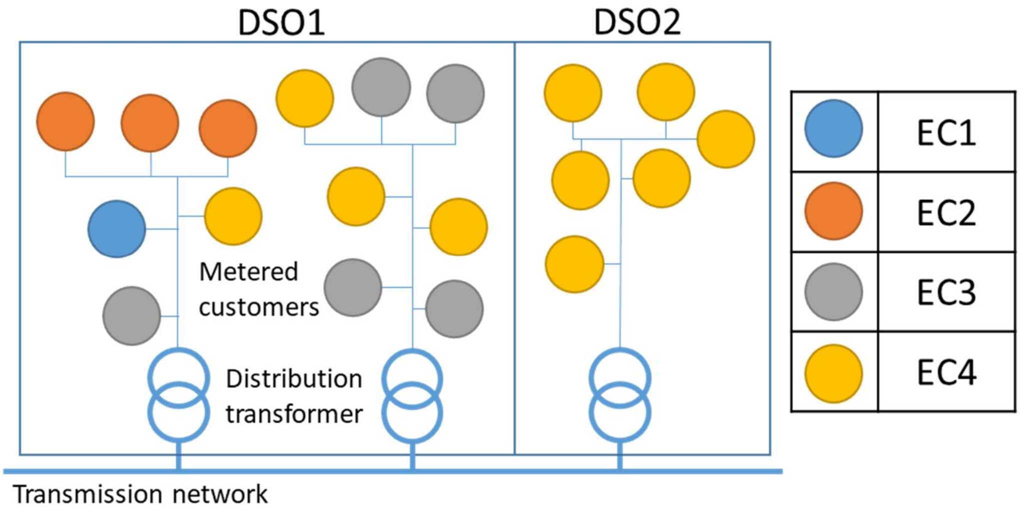

Figure 2. Schematic of pertinent energy community configurations.

4.3. Measures for Encouraging the Growth and Implementation of ECs

It should be noted that this approach is not a one-size-fits-all approach, and the most successful approach will vary by DSO and by member state. Most of the measures to encourage the growth of ECs described in this section have to be understood in context; their effects depend on how they are applied, and they have both positives and negatives. However, this does not prevent us from making some general considerations for ECs. The intention is to present a number of measures and provide a qualitative comparison on the effectiveness of these measures for the EC organizational strategies developed in the previous section.

The overall growth and success of ECs are related to a variety of aspects that are out of scope for this paper, as such, the results from this work should not be taken to indicate overall growth of the number or size ECs in Spain but rather to provide some insight into the relative impacts that specific implementation measures might have on different EC structures.

Additionally, the implementation measures identified in this report represent a subset of all the available implementation measures for ECs. In pursuit of the objective of this report, measures were selected such that they are either not allowed under the current rules or have limited adoption and could benefit from greater attention either legislatively or through business case development. For instance, utility bill reduction through demand charge management and time-of-use optimization is something that interested ECs can take advantage of right now and is equally accessible by ECs with different organizational structures. Even though it is important to the value proposition of ECs, and changes to the rate structures can have an impact on EC growth, since the measure is currently allowed and equally accessible, it is not included in this paper.

The implementation measures can be separated into two categories: Market aspects and Regulatory, legal, and social aspects. While much progress has been made regarding enabling ECs to access electricity markets, including wholesale and flexibility markets, there are still relatively few communities engaging in active management of this kind [56]. This underscores the importance of considering these topics. Similarly, peer-to-peer markets, aggregation, tax credits and incentives, and ancillary market participation are recognized as key-value propositions for energy communities which is why they are considered in this section [39,57].

4.3.1. Market Aspects

Wholesale market access. The CEP and specifically EU Directive 2019/944 encourages member states to allow consumers to participate directly in wholesale markets by adjusting consumption according to market signals. While the Member States have a process for joining as market participants, the requirements are not suitable for individual consumers though there are some Member States that allow aggregation of demand and flexibility resources as a mechanism to access markets. Spain has made some strides toward codifying aggregation and the entity of an independent aggregator, but as per Ley 7/2021, the plan for reform of energy market participation for consumers through aggregation and data access will not be ready until May 2022. The wholesale market access implementation measure represents the ability for consumers to access wholesale markets directly or through independent aggregators.

Local flexibility markets. Consumers and independent aggregators can also offer their demand, generation, or storage flexibility to meet the needs of local markets. There are a wide variety of methods for implementing flexibility markets [58,59], but ultimately local markets represent a way for ECs to provide flexible services to support the needs of other market players. These markets can result in lower system operating costs and potentially defer transmission, distribution, or generation investment. This measure specifically represents the development or improvement of local markets to provide flexibility for balancing or congestion management, while the following measure explores capacity markets. At present, Spain does not have any local flexibility markets though there are ongoing projects that are paving the way for the eventual development of local markets, including eNeuron, CoordiNet [60], INTERRFACE [61], and OneNet [62]. Local markets facilitate the interactions between the DSO and consumers and could also be used to facilitate transactions between different ECs.

Capacity markets. To support long-term resource adequacy, the system operator could implement a capacity market. According to the EU 2019/943, annual resource adequacy assessments should be conducted by system operators to better understand the need and the benefit of implementing capacity markets [63]. Extending capacity market participation to ECs would increase the visibility of EC assets and behavior to the DSO and TSO. These markets could lower the cost to ensure system reliability, and similar to local flexibility markets, they could defer transmission, distribution, or generation. Capacity markets also may have rules that prohibit variable renewable generation from providing capacity or prorate their credit level based on availability [64].

Multisector market coordination. This measure involves the integration of markets for different sectors, including heating, cooling, natural gas, water, communication, other industrial products, and mobility. This measure could involve, allowing more complex bids that include quantities in different markets and cross market settling that achieves the lowest cost across multiple markets. Given that constituents of ECs must provide or contract for a collection of different services in different markets, this step has the potential to lower costs for community members while also increasing flexibility offerings in each market. Markets do not exist for all of the identified items, and there is not always an option to exchange products between these markets (e.g., if the community does not have distributed heating or cooling systems).

4.3.2. Regulatory, Legal, and Social Aspects

Enable peer-to-peer trading. P2P trading allows individuals, ECs, or other entities to trade energy or services with each other. This can be performed in a market or through separate contracts. As these trading schemes are still in the development phase, there is not yet a consensus on the most appropriate strategy though there are several European projects that include a part of the project that focuses on decentralized market concepts that include P2P trading [60–62]. From the EC perspective, one of the deficiencies of the self-consumption strategies is that if one cannot consume all of one's energy, one is either compensated at a lower rate than the retail rate that one pays for electricity (e.g., in Spain, compensation is based on the wholesale market price rate with some adjustments for deviations) or is not compensated at all. P2P markets could allow consumers to receive a higher rate for their surplus generation.

Enable aggregation. European Directive 944/2019 defines independent aggregators as participants who combine a collection of loads or generations to perform different activities in the energy markets [10]. There are different functions associated with aggregation. Demand aggregation is related to market participation and combining different loads to bid in flexibility markets [24]. Current definitions of aggregation are focused on market participation, but its functions could go further in the future. Enabling the formation of aggregators could play an important role in encouraging the market participation of citizens, ECs, and microgrids [7,27]. This measure focuses on further defining and expanding the role that independent aggregation can have on enabling market access to ECs and will have an impact on several of the measures already mentioned, including wholesale, local, and capacity market measures. It is important to note that under the current legal definition, a supplier cannot also be an independent aggregator for the consumers that they serve. This means that EC organization Strategies 1 and 2 above can act as independent aggregators, while Strategies 3, 4, and 5 above cannot act as aggregators for community members and would instead need to rely on contracting with an independent third-party aggregator.

In some countries, the role of the aggregator is still poorly defined. In some cases, getting the proper legal framework into place needs to be established, and in other cases, there are regulations, but perhaps they are too general, and the uncertainty and lack of information prevents market participants from performing this role [6,12]. This is the case in Spain where the independent aggregation was initially defined in Real Decreto-ley 23/2020; however, it is still waiting on the completion of one of the requirements of Ley 7/2021 that will result in a proposal to promote consumer participation in the energy system including through aggregation, amongst other things by May 2022.

Tax credits and incentives. Tax credits and incentives can be an effective way to encourage the achievement of energy or environmental goals or the greater development of nascent technologies. However, the outcomes are strongly dependent on how the measures are implemented. Tax credits or exemptions for ECs or other renewable initiatives have been identified as promising techniques for ECs [12,33]. These methods can be very important for the initial development of small communities [8,13]. Consideration should be given to credits and incentives for equipment, land and property, operation, and income.

Self-consumption. Self-consumption, similar to tax credits and incentives, has been an effective way to increase consumer-sided installation of PVs. As discussed in Section 3, self-consumption involves simplifying the process by which consumers install, connect, and utilize local renewable generation resources. Collective self-consumption allows groups of consumers, potentially at different locations on the grid, to leverage the generation from a single renewable resource after meeting all of the conditions (described in Section 4.2 for Spain). Self-consumption and collective self-consumption have been taken advantage of by most of the ECs in Spain. This measure involves implementing a self-consumption policy and expanding beyond its current state in the European Member States. For example, there are aspects that regulators need to consider to equitably allocate costs and benefits. Some of these include differentiated prices for retail electricity, reduction of administrative burden, and avoidance of strong disincentives for large systems [12].

Strong local community. A strong community of good leaders, people with technical knowledge, and local companies represent a good formula for the development of an EC [13,33,36]. By bringing together local resources, encouraging local jobs, local movement of goods, services, and funds, ECs can help drive the local economy [53]. This measure is focused on understanding the relative impact that a strong local community can have on the success of an EC. This measure applies to both RECs and CECs, though it is worth mentioning that while both CECs and RECs seek to provide environmental, economic, and social community benefits to members or shareholders or the local area, RECs are more focused on local communities with a stipulation in the EU Directive 2019/944 that RECs will be controlled by "shareholders or members that are located in the proximity of the renewable energy projects".

5. Comparison of Community Structures and Implementation Options and Discussion of Resulting Implications

This section explores the relative impact that implementation measures will have on different organizational strategies for energy communities and is intended to aid policymakers in their decision process. The following tables include three delineations to qualitatively measure the impact—red (and 0) means very little, or zero impact, yellow (and 1) means some degree of impact which often depends on several factors (e.g., ability to aggregate consumers), green (and 2) means that this measure likely will have a significant impact. Table 2 presents a summary of the impacts of market-related measures on the five organizational structures.

Table 2. Summary of the qualitative impact of market measures on EC organizational strategies.

Market Measures	Strategy 1 Single-Metered Consumer	Strategy 2 Multiple-Metered Consumers	Strategy 3 Supplier + Consumers	Strategy 4 Supplier + Producer + Consumers	Strategy 5 DSO + Supplier + Producer + Consumers
Wholesale market access	0	1	1	2	2
Local flexibility markets	1	2	2	2	2
Capacity markets	0	0	0	2	2
Multi-sector markets	1 †	1 †	2 †	2 †	2 †

† A distinction is made between RECs and CECs. CECs can only participate in services related to the electricity sector, while RECs can engage more broadly in the provision of multisector services.

Wholesale market access. Based on the minimum bid requirements, including size, response time, or duration of response, a single consumer or even small groups of consumers typically do not have enough demand or production capacity to participate in wholesale markets. In the case of the Spanish energy market, the minimum resource bid capacity is one megawatt [65]. That would require 200 residential PV systems (5 kW each), 416 EVs (2.4 kW, level 1 charging), or 2 thousand flexible appliances (0.5 kW each). This represents a challenge for single consumers and small ECs. The challenge could be alleviated for those groups if they are able to act as an independent aggregator or to contract the services of an independent aggregator, as aggregators could enlist a collection of consumers and ECs to participate. Additionally, for Strategies 1 and 2, the availability of self-consumption and collective self-consumption reduces the importance of access to these markets; however, as these communities expand beyond on-site renewable generation to include large flexible loads and energy storage systems, access to wholesale markets may improve the financial viability for some ECs. This measure relates to both RECs and CECs since the European directives encourage equal access to markets for all participants.

Local flexibility markets. Depending on the regulations and bid requirements, single and multiple consumers are more likely to be able to bid into this market. Local markets with smaller balancing or congestion needs can also have smaller or no minimum bid size. Thus, organizational Strategy 1 is more likely to be allowed to participate in local markets than wholesale markets, while Strategies 2, 3, 4, and 5, with a larger resource potential, are more likely to be able to take advantage of local markets than single-metered consumers. Similar to the wholesale market measure, this measure relates to both RECs and CECs.

Capacity markets. Similar to energy markets, capacity markets often have a minimum bid size which will constrain smaller systems from participating. In addition, if those systems are variable renewables, the size of the system required to meet the bid size may be larger than the installed capacity as described earlier. Since many ECs have installed PV or wind, this may make achieving minimum bid capacity difficult. Single users, multiple users, and even suppliers may not have enough firm capacity to bid into capacity markets, while it is likely that a system that includes larger generation assets, as defined in Strategies 4 and 5 are most likely to benefit from the implementation of rules that allow EC participation in capacity markets. As with wholesale markets, the use of aggregation services could ease the size issues but would require steps to reduce the risk of not delivering on the part of the aggregator. Similar to the previous measures, this measure relates to both RECs and CECs.

Multisector markets. One challenge with the item is that most multisector markets do not have ubiquitous delivery, so they are fragmented and often require special infrastructure to deliver products or services. For single-metered consumers and multiple-metered consumers, this measure would allow access to new markets, but the integration of small devices will cost proportionally more than for larger users with larger and fewer devices. However, the development of multisector market measures could result in the acquisition of new resources or impact the sizing of community resources to increase participation in new markets. Adding the supplier or producer roles further enhances this effect of acquiring new assets in ways that augment their positions in these markets (e.g., install a solar thermal plant instead of PV and connect the thermal output to a nearby thermal load). In addition, the supplier can offer incentives for participation through rates in ways that single and multiple-metered ECs cannot. The results for this section apply only to RECs which can engage in multisector activities (e.g., electricity, heating, cooling). CECs can only participate in services related to the electricity sector.

Table 3 presents a summary of the impacts of regulatory, legal, and social-related measures on the five organizational structures.

Table 3. Summary of the qualitative impact of regulatory, legal, and organizational measures on EC organizational strategies.

Regulatory, Legal, and Social Measures	Strategy 1 Single-Metered Consumer	Strategy 2 Multiple-Metered Consumers	Strategy 3 Supplier + Consumers	Strategy 4 Supplier + Producer + Consumers	Strategy 5 DSO + Supplier + Producer + Consumers
Enable P2P trading	2	2	1	1	0
Enable aggregation	2	2	1	1	1
Tax credits and incentives	1	1	1	1	1
Self-consumption	2	2	1	1	0
Strong local community	2	2	1	1	0

Enable P2P trading. Enabling P2P trading will have an effect on all community implementation models; however, single and multiple user models are likely to be more strongly affected. Much of the impact depends on how the P2P trading is implemented and the level of coordination with affected parties (e.g., supplier, DSO, and TSO). Single and multiple users have limited resource capacity, which can make it challenging to meet the minimum bid size for wholesale energy, capacity, and other markets, so P2P trading represents an opportunity for them to purchase or sell power with the preferred environmental properties or at a preferable rate compared with retail tariffs. Communities that act as the supplier (strategies 3 and 4) are likely to have more limited economic benefits from the development of P2P markets as compared to strategies 1 and 2 since the supplier sets their own tariffs and pulling consumer transactions off of their rates into bilateral agreements with other consumers could reduce their revenue or encourage the purchase of electricity from outside of the community, if allowed. Finally, the benefits to community models that include DSO services are strongly tied to how the P2P markets are implemented. As an example, if the P2P trading is coordinated with the DSO, it is possible to enhance observability into network operation and benefit the DSO; however, if there is more limited communication of P2P trade results, then the DSO does not have more visibility into network operation which can negatively impact operation costs, reliability, and system planning. While EU directive 2018/2001 regarding RECs mentions peer-to-peer trading directly, both the directive 2018/2001 and the directive 2019/944 (related to CECs) ensure access to "all electricity markets", meaning that RECs or CECs can benefit from developments in this space.

Enabling Aggregation. By combining multiple flexibility assets from different entities through aggregation, an EC is able to develop a larger portfolio for participating in energy markets. While a single or small collection of consumers may not have enough capacity to meet minimum bid requirements in each market, combining resources allows for a sufficiently large bid. All five organizational strategies considered here could potentially contract with an independent aggregator, while only Strategies 1 and 2 could assume the role of an independent aggregator. Additionally, working with an aggregator that provides management of flexible assets could offset the costs of portfolio management and allow participation in additional markets that the energy community had yet to consider. As such, aggregation is generally beneficial for small communities or communities without active portfolio management. Aggregators can also support suppliers and the DSO by identifying and capturing flexibility from consumers that a supplier or DSO would otherwise have to do themselves. As mentioned in the peer-to-peer trading measure and the section of the market, the EU directives for RECs and CECs ensure access to electricity markets either "directly or through aggregation", thus this measure applies to both RECs and CECs.

Tax credits and incentives. The development of tax credits and incentives to support energy communities has the potential to benefit all organizational strategies presented here. The extent of benefit depends strongly on the method for implementing these measures. A few examples across the spectrum of solutions include: (1) If a tax credit is implemented that applies to renewable generation or storage technologies. While the implementation appears similar across organizational strategies, the impact would be based on the tax burden. A large organization with a large tax burden could apply this more easily, while a small organization with limited capital purchases or revenue may have a greater challenge to receive the full benefit. (2) If the tax credit or incentive is based on investment in the local community or low-income areas. This would generally favor single or multiple users who are very focused on a specific area. Supplier and DSO models may need to actively tailor their planning strategy to accommodate the rules in order to receive the full benefit. (3) A case that requires emissions offsets from energy purchasers. The Supplier or DSO + supplier models would require additional effort to tailor their generation portfolio and account for the required offsets. In the end, the costs could be transferred to the consumer, so care must be taken that the legislation is written in such a way that ensures consumer benefit. The three hypothetical cases illustrate the range of potential impacts that are tied to implementation—large entities could benefit in the case of the first and third or could favor small entities in the case of the second. While it is left to the discretion of lawmakers whether RECs or CECs are eligible for tax credits and incentives in principle, this measure can apply to RECs or CECs.

Self-consumption. Implementation of self-consumption measures has been developed and demonstrated in several countries, including Spain. ECs across the range of organizational strategies explored in this study leverage self-consumption or collective self-consumption mechanisms as a way to maximize renewable production and reduce their electricity bills. While this may be the case, single-metered consumers and multiple-metered consumers have few other options for reducing costs. At the same time, suppliers can tailor utility rates, large producers can engage other markets, and DSOs can encourage local market development as demonstrated with Strategies 3, 4, and 5, respectively, so the benefits are potentially larger for Strategies 1 and 2. Additionally, in the case of Strategies 3, 4, and 5, the use of self-consumption changes the consumption pattern and can reduce the overall purchase of electricity which requires consideration when setting up energy purchase contracts and setting electricity rates for suppliers and DSOs. In principle, both RECs and CECs can participate in collective self-consumption; however, since there are no geographic restrictions on CECs, community members could be restricted from participation in collective self-consumption based on the limitations for self-consumption itself (e.g., less than 500 m from the producer to the consumer).

Strong local community. The presence of a strong local community with vocal advocates is often the genesis for energy communities, particularly those that place a high priority on social impacts. Thus, a strong local community has a more significant impact on local collections of users. As the organizational structure gets larger (including the role of supplier and the DSO) and more complex, the impact of the local community is less certain. As the percent of voting power for each consumer reduces, the goals and priorities of the broader community may not reflect those of that user, and in this way, community members could grow more distant from the impact of the local community. This measure can apply to RECs or CECs but is most relevant for RECs. Similar to the previous measure, since CECs do not have any geographic limitations, it is possible that CEC members are not in the same region, which would limit the impact of a strong local community.

6. Conclusions

Energy communities represent a promising solution that could lead to increased shares of renewable generation in the electricity system, self-sufficiency, and greater control and flexibility of the energy system. ECs represent a vehicle to achieve both the local energy and environmental goals of the ECs as well as broader regional and national goals, along with more equitably distributing costs and revenues between all parties on the energy system.

This paper first reviews the regulatory status of ECs in Spain, identifying the European directives, Spanish laws, royal decrees, policy guides, and public consultations that establish the current regulatory framework for ECs. Then a formalized method for characterizing different energy community structures is developed, and a qualitative assessment of the impacts of different measures to encourage energy communities with respect to their organizational structures is provided. To accomplish this, a description of the roles of the energy system is detailed, from which five EC organizational Strategies are developed. These Strategies consider different combinations of the identified roles in the energy system and include (1) a single-metered consumer, (2) multiple-metered consumers, (3) supplier plus consumers, (4) supplier plus producer and consumers, and (5) DSO plus supplier, producer, and consumers.

While the expansion of ECs continues, they remain a nascent solution with their success heavily influenced by legislation and regulation. Thus, a set of market and regulatory, legal, and social measures are developed that could aid in accelerating the growth of ECs.

The qualitative impacts of these measures for ECs are compared across the five organizational Strategies. Findings suggest that the market-focused measures including wholesale, local, capacity, and multisector markets favor larger, more integrated communities with a larger role in the energy system (e.g., supplier, producer, and DSO), while the regulatory, legal, and social measures, including peer-to-peer trading, aggregation, and self-consumption, favor smaller, more distributed communities (e.g., single or multiple-metered consumers).

As policymakers begin implementing policies to encourage ECs, the timing for the progression of policies can steer how ECs grow and evolve. For instance, implementing market measures before enabling aggregation or P2P trading could result in favoring the larger, more integrated EC organizational Strategies while developing policies that support strengthening the local formation of energy communities, and the development of collective self-consumption could favor the development of smaller communities. These are not inherently bad outcomes depending on the goals of the agencies in charge of implementing the policies, but policymakers should be cognizant of the progression of policies in order to elicit the desired outcomes with respect to EC growth specific to their region or country and its goals.

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