State of the Art in Energy Communities and Sharing Economy Concepts in the Electricity Sector

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***Abstract*—Due to high penetration of distributed renewable energy resources and their inflexible dispatch nature, modern and future electrical grids are facing technical challenges. New participants can offer the flexibility required by the grid through investments in energy storage and demand response capabilities. This article provides a comprehensive review on the concept of Energy Communities, their technical and economic motivations, available resources in the literature, trading schemes, price negotiation algorithms, and benefits for the grid. Furthermore, this review describes the policy framework in the European Union to make Energy Communities a reality. Moreover, a brief survey of related projects over the world is presented, along with a discussion around benefits, obstacles, and future research opportunities in this area.**

***Index Terms*—Communities, electrical engineering, electricity supply industry deregulation, energy management, energy resources, energy storage, market research, power system economics.**

I. Introduction

The ENERGY sector has been traditionally managed in a centralised way where a limited number of participants are involved. As energy needs to be transported long distances from big generation centres, there are four main businesses associated with the path the energy has to follow to arrive for the final consumer: generation, transmission, distribution, and supply.

Things started changing with the appearance of alternative sources of energy: it is now possible to generate electricity with more easy-to-access primary sources of energy (i.e., sun's radiation, wind, sun's heat, etc.), ultimately making it possible for the energy sector to shift towards a more decentralised scheme [1], [2]. There is no need to transport electricity over long distances. With a reasonable investment, any given user can generate and consume electricity in their property at a better price, virtually eliminating the four main businesses of the centralised scheme.

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Additionally, it is technically viable to produce electricity beyond the user's own needs to provide for nearby users, extending the benefits to others. However, different users are normally connected physically through the centralised scheme's grid, this means the centralised scheme sets the rules for that provision of electricity, generally making the idea of producing extra electricity impractical. It is not profitable for the small generator with regulations that protect the interests of the centralised scheme, as discussed in [3].

Framed in this, it is important to explore alternative business models for these users to aggregate their resources, and level with the traditional participants within the energy sector both technically and economically.

There are a number of relevant review papers recently published in the literature ranging from peer-to-peer (P2P) projects and traits [4], challenges and opportunities for blockchain technologies in the energy sector [5], smartgrids and electricity markets framed in the European context [6], to issues, drivers and technologies relevant to microgrids [7], all these address precursor topics for Energy Communities. Furthermore, reviews conducted in [8] and [9] offer an initial assessment of the economic value, structure, governance, and goals of virtual power plants and photovoltaic generation, respectively, combined with sharing economy concepts in the European context. However, the authors could not find a review that encompasses all the relevant topics and provides an overview of challenges, opportunities, benefits, and obstacles of Energy Communities.

This article aims to close this gap by compiling the resources already in the literature, exploring current and future business models in the electricity sector, including a relevant outline on policy and regulations in the European Union, and updating the survey of relevant projects, all this while putting the motivations and potential benefits of sharing economy concepts in the centre of the discussion.

II. Motivations

A. Technical and Network Infrastructure Impacts

1) Local energy trading will facilitate energy exchange from nearby agents thus helps reducing transmission distances for electrical energy and the corresponding reduction in electrical energy losses [10], [11].
2) Reductions in line and transformer loading are expected as a result of a more localised balancing of demand and supply. This will help reduce network congestions if local

energy trading effectively balances demand and supply at the distribution level [12], [13].

3) The need for infrastructural upgrades and installation to cater for the increasing load demand in a conventional way. P2P energy trading will remove such need as local energy exchange between prosumers reduces the burden on conventional generation resources and hence on existing lines.
4) There are operational impacts of these energy trading systems on to the existing grid, energy exchange between consumers, producers, and prosumers will significantly change the power flows in a way that it will impose hard technical constraints over the network. If there are significant changes in system power flows because of local energy trading, this will affect distribution network voltages, network congestions, system protection, fault recovery, and reliability [11], [12], [14]. Detailed modeling and simulation of the distribution networks will be necessary in order to assess these technical impacts and to provide confidence that local energy trading will not cause adverse impacts to power supply reliability.

B. Economic and Sustainability Impacts

1) The consumers will observe the reduced costs of electricity. This will be a result of the possible removal of some of the intermediaries in the electricity market (e.g., the Bank Payment Service Provider, Electricity Retailer, and Traders). The savings from the removal of intermediaries together with the feed-in tariffs for a local, small-scale renewable generation will significantly reduce costs.
2) Consumers will have more alternatives to choose the provider of electricity with new business models available in the energy market. Decentralised electricity market structures typically involve many smaller prosumers and Energy Communities becoming active market participants [15].
3) Local energy trading will offer effective energy balancing and will reduce dependency on the traditional generation. This is envisaged to improve energy security and independence. This is also relevant in the case of isolated and island systems, which are located in the periphery of the electricity networks, and are much more vulnerable to supply disruptions.
4) The implementation of such local energy trading systems will involve certain costs which may include the cost of installing additional metering hardware and home energy management devices, and information and communication technologies based services for the local energy trading platform. It is important to consider that implementation of such systems and associated hardware should be viable economically and also feasible cost-effectively for large scale implementation [14], [16].
5) New business models will reduce resistance from incumbents in the energy industry whose business models may be threatened by local energy trading. This is a step forward for entities such as Distribution System Operators and Transmission System Operators to encourage the further development of Distributed Energy Resources and to adjust their business models accordingly. In contrast, direct P2P local energy trading platforms could provide a significant threat to the business models of electricity retailers, traders, and bank service providers.

III. Sharing Economy

The fact that traditional schemes of energy generation linger despite more environmentally friendly alternatives is attributed not only to technical and regulatory reasons, it is human behavior, as discussed in [17]. Since the environment is a common good, individuals are encouraged to abuse it for their individual profit and to neglect its maintenance and renewal, ultimately sacrificing common interests, and their own future individual interests (i.e., when a finite resource like the environment is shared, it is abused as an infinite resource).

Nonetheless, it is possible for individuals to manage efficiently common resources by creating bottom-up institutions where rules are established and the use of shared resources is organised for long-term sustainability [18]. This concept is known as a Sharing Economy, it has precedents in various sectors and it is based on prioritising social benefit, environmentalism, and governance of individuals and communities over profit [19]. However, for the energy sector, the concept of a Sharing Economy is new.

IV. Energy Communities

Framed within the concept of Sharing Economies, an Energy Community is defined as a form of a community-driven institution taking social control of shared energetic resources through decentralisation. Individual consumers, producers, and prosumers located in an enclosed topology can create such space to develop independent initiatives, to actively contribute towards a more sustainable paradigm.

As governments commit to sustainability goals on a national level (e.g., fulfilling a set percentage of the energy requirements of the country using renewable energy resources), Energy Communities can develop their own goals and plans to achieve them, driving change locally through the aggregation of resources. This means that users within a community can enjoy the benefits of the energy transition beyond the economic perspective, while they willingly acquire a number of responsibilities as well, the more active their participation is [18].

In contrast with microgrids that aim to aggregate power, Energy Communities appear as legal entities that search the aggregation of energy resources, and through this aggregation, they can reduce power prices and power peaks [9]. The focus of this section is to offer an overview of the main components (see Section IV-A), functionality (see Sections IV-B and IV-C), and implications for participants (see Section IV-D).

A. Resources Within an Energy Community

Resources can be owned individually and managed by the community, or they can be owned and managed by the community; regardless of the ownership, the resources are agreed to be dispatched centrally following a set of rules agreed upon the creation of the community. Any element that can directly or indirectly change how power flows in and out of the community is deemed as a resource, the most common are as follows.

1) Distributed Renewable Energy Resources: According to the literature, renewable energy generation comprises energetic resources that can be renewed within the lifespan of a human being [20], [21], this includes geothermal heat, waves, tides, wind, sunlight, etc. As discussed previously, some renewable energy sources have an important advantage over traditional generation schemes: availability of the resource near consumption centres. Since most of the renewable energy resources that will be found within an Energy Community depend on weather conditions, forecasting plays an important role [22]–[24].

2) Energy Storage: It is clear that one of the great challenges with distributed generation is how in general it requires flexibility from the system operator to respond efficiently when facing instant unbalances between supply and demand [2]. Implementing energy storage technologies can potentially counteract these sources of uncertainty as seen in [25]. Storage units are commonly found within the installation of an individual user, however, communitarian storage resources are a growing possibility [26].

3) Demand Response: Normally, a utility user has regular patterns (based on their daily routine for residential users, or their products and services lifecycles for commercial and industrial users), this user is considered to have demand response capabilities if it is able to make changes to these consumption patterns based on economic or technical constraints [27]. The objective is generally to maximise savings or optimise usage of energy generated on-site. This results in multiple benefits for the user and the system operator, as discussed in [27] and [28].

4) Energy Management Systems: Energy Management Systems (EMS) are control, communications, and measuring systems used to operate the individual variables in a microgrid [29]. In general, it is an algorithm that based on current conditions from sensors, can control variables in the system to achieve the desired state [30]. If this application on microgrids is scaled to an Energy Community and the inherent rules are treated as constraints for the EMS, all the available resources can be managed with minimum supervision. Considering that an Energy Community includes several consumers and prosumers, the first objective of an EMS is to match supply and demand within the community, and distribute benefits to achieve social welfare (e.g., the EMS can schedule resources when the system has demand response capabilities, and storage units if available). Different approaches for this are available in [31]–[36].

B. Trading in Energy Communities

Different cooperative market structures are based on the involvement of the agent/prosumer individually and as part of a community. The prices of selling and buying between these agents are regulated to incentivise each in such a fashion that both seller and buyer can maximize their social welfare. This section explores the particularities of trading within Energy Communities.

1) Business Models: As discussed in [14], the fundamental categorization of business models suitable for electricity markets is based on which actors participate as active players (e.g., customers, investors, utilities, retailers, etc.). Only three models fit properly with the nature of the electricity market as follows.

1) Business-to-consumers (B2C) models, where the electricity flows in one direction and revenue flows in the opposite direction. In this model, an intermediary is in charge of the financial transaction (i.e., the role of supplier).
2) Consumer-to-consumer (C2C) models, also known as P2P, where participants have similar interests and values to trade and there is no need for an intermediary. Participants may change their roles, either selling or buying depending on the availability of the asset. Electricity and money flow in multiple directions within the consumer spectrum.
3) Business-to-business (B2B) models, rising within the energy market. Businesses part of this model, act as "platform" companies providing services to different actors such as new applications of renewable energy sources as [37], smart meter optimization as in [38], intelligent energy storage and energy management as [39], data integration and management in [40], energy balancing platforms as [41], etc. Within the B2B model, revenue flows in multiple directions, on a larger scale compared to the C2C model.

Most residential and industrial users traditionally fit into the category of "Consumer", limiting them to interactions within the B2C and C2C models. When a number of users agree to become an Energy Communities, a new possibility arises to interact within the B2B model. This is the main difference Energy Communities have with microgrids and smartgrids, as an entirely new business model is open for participants.

There are security concerns for Energy Communities and trading, to address this, research is focusing on Distributed Ledger Technology applications such as blockchain, with decentralised decision-making processes, as discussed in [5], [10], and [42].

Different interactions between users depending on the business model are illustrated in Fig. 1. Within B2C models like traditional energy markets, transactions of electricity are conducted through the system, this is a highly regulated market with fixed prices for each transaction.

C2C models, as in emerging P2P markets, are possible within a microgrid as a P2P System, outside the microgrid the transactions are still conducted similarly to the B2C model. Different techniques to allocate use of network charges necessary in the B2C model.

A B2B model makes it possible for additional interactions, as seen in Fig. 1. Following the rules of the community, the remaining resources can be transacted with the system or individual users. Additionally, the Energy Community can sell ancillary services to the system and other participants.

2) Price Negotiation: It is important to mention that within these business models, there are various strategies in the literature for the allocation of prices and the assignment of buyers and sellers (e.g., retail oriented markets, vendor oriented markets, blockchain-based markets, etc.), as seen in [14], [15], and [43]–[45] and optimization techniques to clear the market in one-time

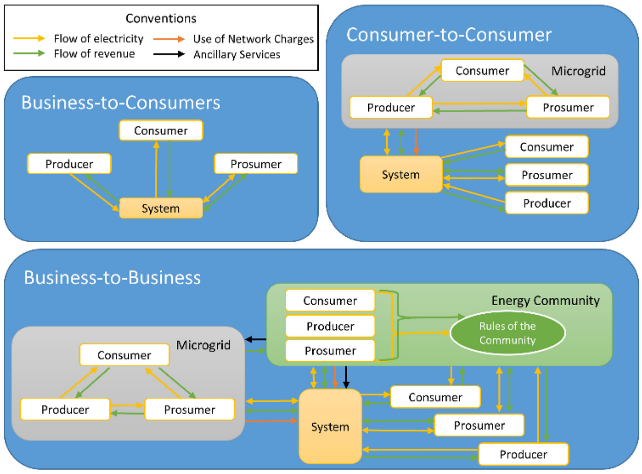

Fig. 1. Interactions between users in different market models (B2C, C2C, and B2B).

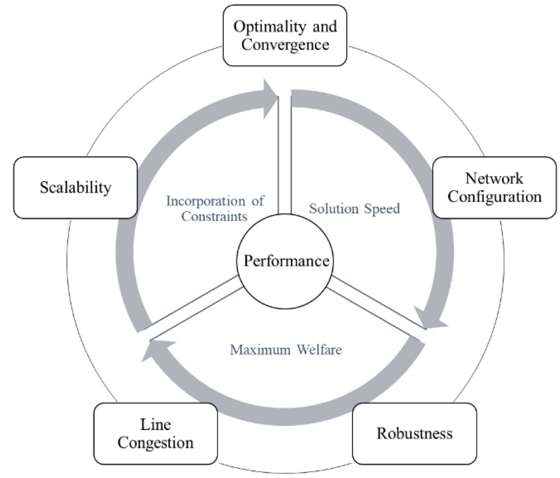

Fig. 2. Market and Algorithm Performance.

slot [43]–[45]. This means that while the possible transactions within the B2C trading model are highly regulated, C2C and B2B models correspond to more open markets where the rules can be agreed upon by participants.

The goal of developing/choosing a proper optimization technique is to reach the optimal solution to clear the market in a one-time slot [44]. The optimization algorithms are developed in two ways: centralized, in which all the information of the market players/participants is shared with a central entity to solve the problem, or decentralized in which all the calculations and data exchange is done by the individual market player or agent. In this scenario, alternating direction method of multipliers (ADMM), distributed consensus + based algorithm and consensus + innovation method are promising candidates [14]. All these methods are iterative in nature. ADMM method is prevalent in the literature and several simulation studies have been carried out on small test networks. ADMM faces challenges considering the number of iterations and the solution time will increase when several market players increases. Additionally, there is a scalability problem concerning the negotiation process, as analyzed by More *et al.* [46].

A number of studies have presented novel techniques suitable for P2P market structure: A primal-dual gradient method is proposed in [45], as a market-clearing mechanism for the market. The authors claim that the segmentation process in it will provide the sparsification of communication channel/infrastructure and relaxes the computer burden with a large number of players and enhance scalability. The algorithm identifies and separates the local and global constraints and divides the problem into several local ones. The results show that the computational time is still under limit even when the number of players participating is increased to 1000. Additionally, Khorasany *et al.* [45] proposed an adaptive segmentation method where a balanced clustering process is incorporated to ensure supply-demand constraints in each segment. Findings from this article suggest that the algorithm is suitable for both community-based as well as fully decentralized P2P trading. Both of the above techniques do not need any central coordinator, thus complementing the very nature of the P2P energy trading framework. The topic is open for ample research, where future research may include identifying different constraints, e.g., transmission losses, defining the optimal segments in decomposition and additional features may be incorporated with the algorithm.

3) Market and Algorithm Performance: Numerous parameters are assumed to impact the performance of the market and the algorithms, it would be challenging however to identify every single parameter arising from separate goals set by cooperatives in diverse market designs. Rather, defining a layer of performance indices between the performance and the actual parameters will be promising to assess the negotiation process, as depicted in Fig. 2.

Only a few parameters, i.e., optimality, network configuration, line congestion, scalability, and robustness are considered in this article to observe their effect on the following indices.

1) *Solution speed:* Every market desires quick solutions and rapid transactions during negotiation. Convergence to optimal solution requires a number of iterations to clear the market, closely related to the complexity of network. Evolving active network will enable large number of agents' participation in the market, add further transmission paths altering network configuration and scaling up the negotiation process producing low solution speed [45]. Studies comparing a number of distributed (e.g., ADMM) and decentralized market clearing algorithms (e.g., RCI, primal-dual gradient method) concentrates on the similar issues [43], [45], [46]. Solution speed is not solely dependent on processing an algorithm but on the communication and hardware infrastructure. Lack of robustness results in asynchronous behavior of P2P market causing delay in the outcome.
2) *Maximum welfare:* Objective of negotiation is to create a win–win situation for all which is ensured if maximum welfare is attained. Welfare is represented by an objective function of the energy cost and system operation subjected to users' interest and network requirements. Congestion,

one of the constraints whose management becomes quite complex due to possible network configuration [47] transforms an algorithm to become more complex that even converging to local optimality is difficult. Few users' or network requirements are needed to be tradedoff to achieve an acceptable outcome. Lack of robust hardware and communication infrastructure is also known to affect welfare as conventional algorithms are found to exhibit oscillations when finalizing the profit maximization.

3) *Capacity to incorporate constraints:* Energy balance, congestion, etc., are critical in maintaining reliable operation of the system. Two-way power flows in a P2P network demands to keep the constraints under serious check. Thus, negotiation algorithms are pushed to internalize constraints to perform better. Network reconfiguration presents further new and dynamic constraints during transactions eventually disturbing the optimality to reach convergence. This severely affects the algorithms' capacity to incorporate constraints. Scalable algorithms are indeed needed, which can acknowledge constraints of the large market to achieve an optimal solution. Investigation of several decentralized algorithms, as presented in [43], [45], and [46], can be carried out with a different number of constraints to assess this index of performance.

C. Services to the Network

It is known that new Distributed Energy Resources in a traditional grid are associated with a degree of uncertainty for system operators, and such uncertainty can be counteracted through the clustering of resources, adding some benefits from the diversity of demand and supply from aggregation, as discussed in [48]. However, the appearance of Energy Communities in the electricity sector potentially has deeper beneficial impacts for the grid that require further research as follows.

1) Flexibility in Dispatch: With the high penetration of renewable energy sources, the system is expected to rely more on these sources. The services traditionally provided by the grid side, are now needed to be integrated within these variable renewable energy sources (e.g., frequency control, contingency reserves, voltage control, and demand-supply balancing). In order to maintain the resilience and security of supply from these variable renewable energy sources, various changes in existing markets and new technologies have been already proposed in the literature [2].

Currently, if a supply-demand mismatch occurs, it is uncertain how will it be catered immediately in a system with heavily penetrated variable renewable energy sources, since outputs depend on wind speeds or solar radiations. The conventional generation facilities are unable to ramp up or down quickly and efficiently and lack the ability to take advantage of a growing influx of wind and solar power to the grid. Rapid shifting with the weather, the supply of renewable power can be quite changeable, which cannot be addressed by these reserves.

One of the present solutions to this is termed as "flexible power plants" which aims to keep up with the variable outputs of the renewables. These plants that can start, stop or throttle up and down quickly and efficiently. The combined-cycle technology plant in which exhaust heat is captured from the burning of natural gas drives a steam turbine can ramp up mega-watts within a few seconds [49].

On the other hand, energy storage and demand side flexibility can respond promptly to this mismatch and play an important role for future grids with high penetration of renewable energy sources [50], [51]. Future implementation of Energy Communities can potentially eliminate the uncertain nature of renewable energy sources when there is a presence of energy storage and demand response capabilities. The Energy Community's aggregated profile becomes flexible, and it is expected to provide the resilience and security of supply services, reducing the need for "flexible power plants".

2) Demand Curve Flattening: If demand response and energy storage technologies are implemented appropriately, important benefits for the system operator are expected, the most important of which is demand curve flatting [48]. The characteristic peaks and valleys from normal consumption patterns in the load curve can potentially be smoothed [52], resulting in a more efficient generation scheme.

If the demand maximum and minimum over a period are drawn near, the generation installed capacity will be used efficiently, meaning less operational costs for the system operator. Additionally, if the difference between load peaks and base load of the system is reduced, so is the requirement for network reinforcements, delaying long term investments in generation capacity reserves [20].

3) Use of Network Charges: Considering that Energy Communities by definition will use the distribution and transmission grids property of the system operators, it is reasonable to allocate charges for this usage. Baroche *et al.* [53] tried to define network usage cost allocation policy based on four different categories: Total fees, unique cost, electrical distance cost, and uniform zonal cost as explained in [1].

D. Responsibilities in an Energy Community

Since users are expected to sign up voluntarily based on their wish to participate [54]. It is important to state that the benefits associated with an Energy Community come with responsibilities: individual users, the system operator, and the Energy Community itself must agree on a set of rules and principles, these are based on Ostrom's work for Common Pool Resource organizations [18].

1) All the parts involved are in charge of defining clearly the extents of the community and must state: the resources, exclusions, and limitations of each participant. Transparency in this information is vital.
2) All participant must consent that their resource can be managed according to common interests if they wish to, an individual agrees to this as part of the community.
3) The decision-making process on how to use the resources must be collective, each participant has a voice and the community must establish rules to guarantee collective-choice arrangements.

4) Constant monitoring of resources availability and flow must be effective. This monitoring must be reliable and the community is accountable for the right maintenance and safe-keeping of related records. As the information relevant can be sensitive, it needs to be collected, shared, processed, and stored securely, further discussion of the regulations that apply on Section IV-C data protection policy.
5) As each individual acquires commitments in the normal operation of the community, a system of sanctions must be created for those individuals in breach of community rules and commitments.
6) In case a conflict arises in the operation of the community, a cheap and easy-to-access conflict resolution scheme must exist, and the decisions made in this instance are accepted by the community, even if modifications to the initial set of rules are required.
7) The community and its existence must be acknowledged by higher-level authorities, not just the system operator, but regulatory bodies and other relevant entities as well.
8) In some cases where the community requires it for its size, the resources can be organized in multiple layers of nested communities with small decision-making processes in place at the base level.

As these are base guidelines suggested in the literature, more design concerns will prove necessary, and some of the mentioned rules will become irrelevant. However, it is important to understand that individuals voluntarily opt-in for the service and agree to a set of rules that will prove beneficial for the community in the long term, following the rules will be their responsibility. The community, in turn, will be responsible as an institution for guaranteeing a safe environment for all the participants.

V. Policy Challenges

With the creation of the clean energy for all Europeans package [55], the new regulation on the governance of energy from the European Commission grounds EU objectives and goals for energy union, and climate action, aligned with the Paris Agreement and the energy and climate 2030 targets for the EU. Every EU member is required to publish a National Energy and Climate Plan for the ten-year period 2021–2030. In general, the commission recommends member states [56] to take action through policy in the following.

1) The building and transport sectors to reduce the 2030 greenhouse gas emissions target.
2) Targeting ambitious renewable energy share for 2030 with quantified policies and measures around the heating and cooling sector, the transport sector, as well as enabling frameworks for renewable energy communities and self-consumption.
3) Increasing energy efficiency, expressing the contribution as a specific value.
4) Specifying measures around energy diversification to reduce dependency on the gas and oil sector.
5) Funding innovation and research related to the energy union, and creating measurable national objectives for 2030.
6) Delivering on the renewables targets and implementing ongoing interconnection projects as measures to ensure regional cooperation, considering the United Kingdom's transition out of the European Union.
7) Phasing out subsidies, in particular for fossil fuels.
8) Further considering different scenarios and their impact on air pollution.
9) Addressing the impact of the transition of carbon-intensive populations in the region, providing details on social, employment, and skills impacts.

Furthermore, while policy around Energy Communities across Europe is inexistent, Directive (EU) 2018/2001 dictates member states to create a policy framework to promote and facilitate self-consumption, and the creation and development of renewable energy communities, respectively, in Articles 21 and 22 [57]. Many EU member states are on track to create such policy, making Energy Communities a possibility in the near future.

VI. Discussion

As part of this review, the academic and industry sectors were surveyed in search of projects related to the main topics discussed so far. In total, 37 projects with similarities were found around the world, the most relevant of which are registered in Table I with the mapping of topics that each project address.

A. *Future Research Opportunities*

From the surveyed projects, it appears the current focus is on decentralisation, distributed energy resources, blockchain, and smart metering topics. The largest gaps can be found around community generation, pool resources, demand management, and community energy storage. These topics represent future research opportunities as follows.

1) It is unclear how different technologies and components can coexist within a grid in which reliability and security of supply are a priority. For this, it is important to cosimulate technical and economic scenarios from an operational and planning perspective.
2) In a grid with flexible and nonflexible resources power flows will change, this can greatly affect network performance. Assessing this impact and proposing strategies for the future Energy Community to mitigate it is a timely topic.
3) Further research on the development of trading algorithms to facilitate the trading process without violating network constraints is required.
4) As an increase of investments in distributed energy resources is expected, research on the appropriate strategies for allocation of resource is necessary. This must be done considering the governance particularities of sharing economy concepts.

TABLE I
SURVEY OF ENERGY COMMUNITY RELATED PROJECTS

Relevant projects for future Energy Community applications. / **Project Name**	*App/Web based application*	*Decentralised framework*	*Community/Co-op Scheme*	*Distributed Energy Resources*	*Community Generation*	*P2P Trading*	*Power Flow allocation*	*Energy Quality*	*Blockchain/DLT*	*Pool Resource*	*Auction*	*Smart Metering*	*Net Metering w/ DSO*	*Demand Management*	*Load Forecasting*	*Generation Forecasting*	*User Energy Storage*	*Community Energy Storage*	*EV Energy Storage*	*Aggregators/Aggregation*	*Dataflow With DSO*
Brooklyn MG [8, 58, 59]	X	X	X	X		X			X		X	X	X						X		X
sonnenCommunity [4, 8, 25, 60]	X	X		X						X		X		X		X	X			X	
Electron [4, 5, 61]	X	X		X			X	X	X								X			X	X
Greeneum Net Ltd [5, 62]	X	X		X		X	X	X	X			X			X	X					
Hive Power [5, 63]		X	X	X			X	X	X			X			X	X					
EMPOWER [6, 64]			X	X						X	X	X					X	X			X
WiseGRID [6, 65]	X	X		X								X		X			X	X	X		
Synergy [5, 66]	X	X		X		X			X	X		X	X								
NRGCoin [7, 67]	X	X		X			X		X			X								X	X
Spectral [5, 68]	X	X		X					X	X		X		X			X				
Powerpeers [5, 69]	X	X	X	X						X		X								X	
Edream [70]		X	X	X				X	X					X						X	
OLI Systems [5, 71]	X	X		X					X						X	X	X				
Power Ledger [5, 72]	X			X	X				X			X				X	X				
The Sun Protocol [73]	X	X	X	X	X				X									X			
Verv [74]	X			X					X			X		X	X	X					
P2P Smart-Test [75, 76]				X		X	X	X	X					X							
Ecogrid EU [6, 77-79]		X	X	X			X					X		X							
Cvpp [9, 80]		X	X	X	X					X										X	
Kyoto [81]				X	X	X			X			X					X				
Ampere Energy [82]	X			X				X				X				X	X				
BlockLab [5, 83]		X	X	X		X			X			X									
FlexiDAO [8, 84]	X	X		X					X			X									X
Share & Charge [85]		X		X		X			X										X	X	
SunContract [5, 86]	X	X		X		X			X			X									
Brixton Energy [87]			X	X	X								X								X
Dominoes [88]				X				X				X		X						X	
GoFlex [89]			X	X			X	X						X							
ElectriC-Chain [5, 90]		X		X					X							X				X	
Energy Unlocked [91]		X		X					X					X			X				

B. *Benefits and Obstacles for Energy Communities*

Ultimately, as the concepts of sharing markets and community-driven institutions apply in a wide range of spheres in modern society, it is important to discuss the potential benefits this new paradigm has for its individuals in the electricity sector.

1) *Economy*: As social welfare is prioritized [19], a sharing market is not driven by profit and debt. Since needs are shared by all individuals within a community, so are the benefits, therefore, wealth and income will be more evenly redistributed if a sharing market is in place [92].
2) *Environmentalism*: A community that bases its decision-making on long term benefits, acknowledges the environment as a dynamic living organism that has the possibility to provide resources sustainably, optimizing through planning, and forecasting how the resources can be used [19].
3) *Governance*: When a community is empowered to actively make decisions about their present and future, the balance of power shifts away from the state and the power returns to people [93]. If the stabilizing effect of the government remains, the government becomes a partner.

Aside from the benefits it has, adopting a sharing economy represents a number of obstacles, these are present in the form of attitudes that individuals take when facing the opportunity to be part of a community [94], [95].

1) Misinformation plays an important role, individuals either deny their personal responsibility within a community or doubt the impact they can achieve [94]. Furthermore, when they move past these and find motivation, individuals act reluctant because they want to get value for their money and are concerned about the quality of the products and services outside the traditional market, even if this is against their ethical beliefs [95].
2) *Novelty*. A new paradigm means individuals' behavior can be somehow hard to modify. Inertia makes individual players believe that the government and its institutions are in charge of regulation and as a community, they cannot decide how resources are managed.
3) *Institutional resistance*. As the sharing economy intends to replace at least partially the current profit-based economy, there will be reluctance from institutions to allow individuals and their money to make the transition, this is discussed further in [93]. Special attention to this obstacle is required if framed in a society with corrupt institutions, as individual interests play an important role in regulation and government-based decisions.

VII. Conclusion

This review article offers an overview of the main components, participants, market concerns, policy considerations, and a survey of projects with similarities across the world. A recommendation for future research opportunities is issued as a result.

There are important technical and policy challenges associated, however, Energy Communities have the potential to reduce costs of electricity in a number of ways: increasing the amount of locally generated energy and aggregating loads, the amount of self-consumption is increased. The possibility to operate the resources in a coordinated way, allow Energy Communities to include a range of ancillary services as part of their portfolio. Additionally, whether investments are made individually or as part of a community initiative, all participants benefit and can profit from economies of scale.

Pending legislation, Energy Communities (when at least a fraction of the energy needs is produced locally) avoid unnecessary grid fees from large scale transmission.

The implementation of Energy Communities is expected to be linked with an increased interest in distributed renewable energy resources investments, which will in turn help achieve regional and national goals of decarbonisation.

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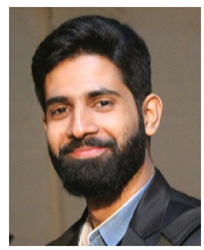

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