BLOCKCHAIN TECHNOLOGY AND PEER-TO-PEER TRADING IN ENERGY COMMUNITIES: A REGULATORY PERSPECTIVE

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Energy communities in the Clean Energy Package and beyond

The European Union's Clean Energy Package aims to bring the European Union (EU) and its member states on track for the 2030 climate targets [1] [2] [3]. Besides other legal acts, the package includes the revised Renewable Energy Directive (EU) 2018/2001 (RED) [4] and the revised Electricity Directive (EU) 2019/944 (ED) [5], both introducing several related new actors to the energy market. EU member states are expected to introduce them on four levels, each of which shares common features but also includes some differences [6] [7] [8]. Opportunities for market participation increase the higher the level, including a wider operational area and thus an increasing number of possible participants:

- **Level 1 (Single houses): the 'renewables self-consumer' (RSC)**, who is 'a final customer [...] who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity' [4].

- **Level 2 (Multi-apartment buildings): the 'jointly acting renewables self-consumers' (JRSC)**, who are 'a group of at least two jointly acting renewables self-consumers [...] who are located in the same building or multi-apartment block' [4].

- **Level 3 (Local or regional communities): the 'renewable energy community' (REC)** with members located in proximity of each other. Participants shall be enabled to self-generate, consume, store, share and sell their produced energy [4].

- **Level 4 (Broader communities): the 'citizen energy community' (CEC)**, which is not restricted in the area of its operation; optionally even spreading across member state borders [5].

In this paper we will focus on peer-to-peer (P2P) trading between the participants, for example by utilizing Blockchain technology. In this regard, only the levels 2-4 are of relevance for the scope of this paper. While the recently completed Austrian research project Blockchain Grid[1] has mainly observed these aspects in RECs [6] [9] [10], the same concepts are expected to be applicable to some extent in the other levels listed above.

Energy communities are gaining significance as energy market players

As part of the energy transition, energy communities may gain significance in the next years to become an essential element of future energy systems. They, for example, contribute to abating the effects of climate change as well as provide local countermeasures against blackouts [9]. They are recognized as important players in several national energy and climate plans [11]. Furthermore, the RED states that [4]:

> *The participation of local citizens and local authorities in renewable energy projects through renewable energy communities has resulted in substantial added value in terms of local acceptance of renewable energy and access to additional private capital which results in local investment, more choice for consumers and greater participation by citizens in the energy transition. […] Measures to allow renewable energy communities to compete on an equal footing with other producers also aim to increase the participation of local citizens in renewable energy projects and therefore increase acceptance of renewable energy.*

The Austrian draft on energy communities

Some of the deadlines for the transposition into national legislation have already passed (end of 2020 for the ED, including the regulations on CECs) while others are approaching (mid-2021 for the RED, including the

[1] Cf. https://www.youtube.com/watch?v=VrD69732Jgg (last accessed on 2021-06-01).

regulations on JRSCs and RECs); however, only a few EU member states have already introduced energy communities to the full extent [7] [8] [12]. For example, the geographical operational area of an REC, the so-called 'proximity criterion', needs to be defined by each individual member state and thus can differ across countries. Only recently, the Austrian draft of the transposition[2] was issued and is expected to come into force in summer or fall of 2021. The maximum operational area shall mainly be defined by using network levels (NLs) as a technical definition of proximity, combined with the concession area of the relevant distribution system operators (DSOs) as a geographical restriction that cannot be exceeded by one REC. Based on that draft, the two operational levels of RECs are depicted in Figure 1. They depend on the network levels they span:

- NL 7: low voltage grid,
- NL 6: transformer level,
- NL 5: medium voltage grid,
- NL 4: transformer level.

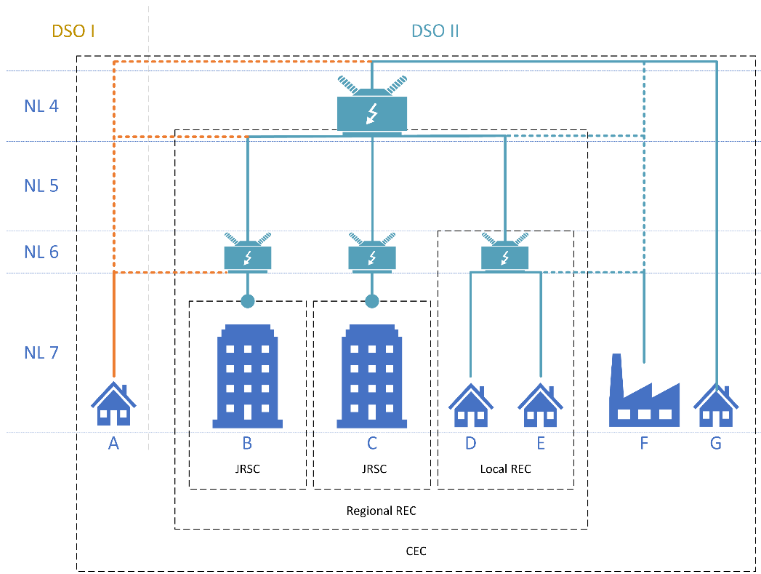

Figure 1: Operational scope of the examined actors according to the Austrian transposition draft [8]

Since local RECs shall be allowed to operate on the NL 6 and 7, and regional RECs additionally on NL 5 and limited parts of NL 4, the other network levels are out of scope of this paper. While financial profits shall not be the primary focus of the community itself but rather environmental, social, and economic community benefits, individual savings of energy costs will indeed be an important factor for possible participants to decide on joining an energy community [13]. As an example, Austria discusses reductions of grid tariffs, taxes, and fees for REC participants: costs incurred by voltage network levels above the one the REC operates shall not be considered. As a result, there are no grid fees to be paid in JRSCs, there shall be lower fees for energy flows within local RECs compared to regional RECs, and there are no grid fee reductions foreseen for CEC' participants due to them possibly spanning an area beyond NL 4.

Structure of an energy community

Concrete community structures may be different depending on whether they are operating in an urban or a rural area; however, in every community there will be some producers/prosumers (e.g., houses equipped with photovoltaic panels), some consumers (e.g., houses as well as e-car charging points), and potentially a (community-owned) storage unit (Figure 2).

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[2] Cf. https://www.parlament.gv.at/PAKT/VHG/XXVII/I/I_00733/index.shtml, 'Renewable Expansion Act', in German (last accessed on 2021-06-01).

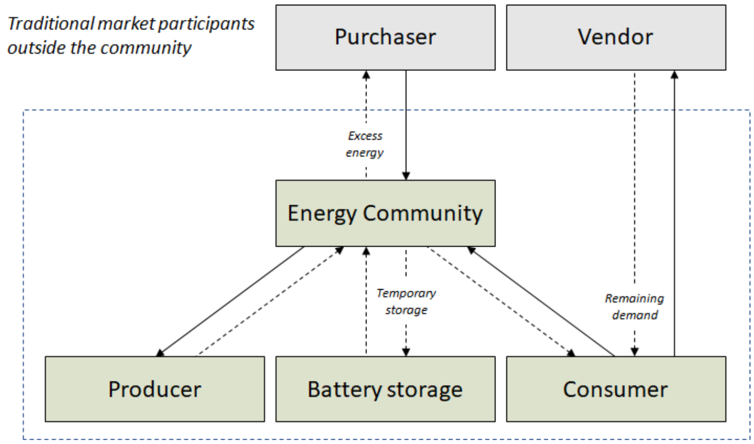

Figure 2: Involved actors within and outside an energy community [8].
Energy flow is shown with dashed lines, cash and information flows with continuous lines.

Excess energy of producers will primarily be allocated to consumers within the community to maximize consumption within a community (e.g., by using P2P trading utilizing Blockchain technology, and in particular smart contracts [9]). This will become feasible in cases (cf. Figure 3) where

- the producer receives more money for selling energy to the community or any consumer in the community than to any other (traditional) purchasers outside the community ($y > x$), and
- the consumer pays less money for purchasing energy from within the community or any producer in the community than from any another (traditional) supplier ($b < a$).

As an energy community is not expected to make a profit, break-even is sufficient ($y < b$). Hence, the community price will be set between the export price x and the retail price a [13] [14]. The energy community can temporarily store energy that cannot be allocated to a consumer at a given time; further excess energy can be sold to traditional suppliers outside the community. Likewise, the remaining consumer demand that cannot be met by the community itself (i.e., its producers and its storage units) is purchased from a traditional supplier.

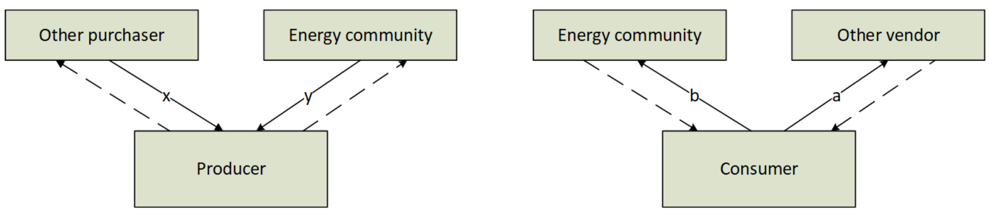

Figure 3: Cost-optimization for producers and consumers in the community [13].
Energy flow is shown with dashed lines, the cash flow with continuous lines.

Blockchain for the implementation of energy communities

The use of Blockchain technology is increasingly trialed and implemented in several areas, including the energy sector [15] [16] [17]. Among other applications, Blockchain technology provides several attractive properties for implementing smart automated applications in energy communities. It provides a trustworthy solution for almost-immediate transaction settlement, transparent accounting as well as dynamic management of grid usage. In particular, Blockchain can enable innovative approaches, such as P2P energy trading or energy sharing concepts within a community [9] [18]. Such applications, however, raise a lot of questions from the point of view of how Blockchain-based solutions for energy communities should be regulated, either by EU regulations, directives, or national regulations. Previous Austrian research projects, such as Blockchain Grid, have already successfully implemented proofs-of-concept for using Blockchain technology in the operation of energy communities [9] [10].

Implications of the EU Directives for the use of Blockchain and for peer-to-peer trading

According to the RED, RECs shall be ‘autonomous from individual members and other traditional market actors that participate in the community as members or shareholders’ [4]. Participation is further restricted to natural persons, small and medium enterprises, or local authorities, including municipalities. Thus, DSOs as well as traditional energy suppliers are precluded from taking part in RECs. In contrast, for CECs, the ED states that only the decision-making powers 'should be limited to those members or shareholders that are not engaged in large-scale commercial activity and for which the energy sector does not constitute a primary area of economic activity' [5]. Suppliers and DSOs would thus be able to participate in a CEC, but they do not have decision-making powers. As a result, there is no specifically designated authority for the operation of the energy community and its technical systems. However, the directives require energy communities to be incorporated in some legal form, such as a registered association or a cooperative society, established by the participants themselves. From this perspective, it seems suitable to use Blockchain technology since no intermediary is required and operations can be conducted without supervision.

P2P energy trading refers to direct energy trading between prosumers and consumers [14]. It is an innovative approach that does not require an intermediate party for the allocation, selling and accounting of energy between these parties. This horizontal agreement between these two 'peers' thus clashes with the traditional vertical structures of the electricity sector [19]. The concept of P2P trading itself is not necessarily restricted to energy communities and their participants; a general architecture of a P2P energy trading model is depicted in Figure 4.

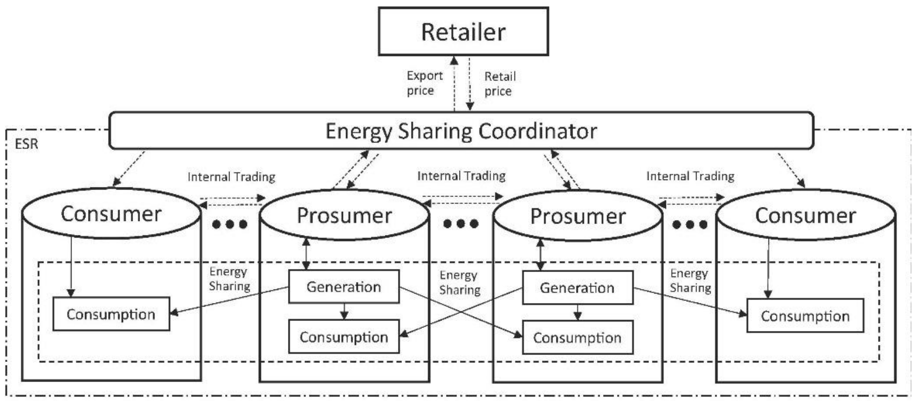

Figure 4: P2P energy trading model [20]

Notably, the RED addresses the possibility of 'peer-to-peer trading of renewable energy' and defines it as [4]

the sale of renewable energy between market participants by means of a contract with pre-determined conditions governing the automated execution and settlement of the transaction, either directly between market participants or indirectly through a certified third-party market participant, such as an aggregator.

This appears to legally consider Blockchain as a subtle enabling technology, including smart contracts. The latter are, however, not (yet) considered as contracts in a legal sense, although the executed code may nevertheless produce legal effects [10] [21]. However, the term 'peer-to-peer trading' afterwards appears only once more in the regulations on 'renewables self-consumers': The Union's member states are thus entitled to ensure those consumers to generate renewable energy, and to store and sell excess production by using renewables power purchase agreements, electricity suppliers and peer-to-peer trading arrangements [4]. However, despite not mentioning P2P trading in relation to energy communities in the directives, it should not be concluded that P2P trading is open only to renewables self-consumers [19]. Neither is it specified in which ways P2P trading shall or shall not take place, for example, by which tools or technologies. Neither does the Austrian draft legislation include any reference to P2P trading, thus exposing a regulatory gap.

Legal aspects of Blockchain use and peer-to-peer trading in energy communities

When deploying Blockchain technology, various legal disciplines (e.g., civil law, consumer protection law, tax law, e-commerce law, data protection law) need to be considered [22]. In previous work, we have focused on a privacy-preserving implementation of an early REC prototype [6]. We showed that the operation of an REC can indeed be implemented in accordance with the legal requirements, although certain compromises will be necessary.

It was shown that energy consumption data of households should be treated as personal data since the high-resolution meter readings by advanced metering infrastructure provides insights into personal habits of consumers concerned [23]. Those smart meters are increasingly rolled out in various countries, including Austria, which legally requires equipping at least 95 % of all metering points with them until the end of 2022. The legally foreseen option to opt-out will not be applicable to participants of energy communities. High-granularity readings of energy consumption (and production) data will anyway be required for an adequate operation of energy communities. However, as the operation and reading of the meters (in Austria) are responsibilities of the DSO, it still needs to be specified when and how data will be delivered to the energy community operator, for example, by applying the existing legal rules for the data exchange between the DSO and energy suppliers to energy communities as well.

Fundamental consumer rights granted by the ED [5] and the General Data Protection Regulation (EU) 2016/679 (GDPR) [24] are not trivial to reconcile with inherent properties of Blockchain. Concerning data protection, only a few problematic aspects regarding Blockchain shall be briefly noted in this paper (see [25] for more details): The GDPR, which is directly applicable in all EU member states, legally requires personal data to be kept only as long as required for the legitimate reason. The 'party connected to the grid' (i.e., 'a party that contracts for the right to consume or produce electricity at an Accounting Point') as defined in the Harmonized Electricity Market Role Model [26] is – due to processing its personal data – the data subject of GDPR. Personal data must be corrected when wrong and can be demanded to be deleted. Furthermore, there must be a 'controller' as a responsible party for compliance with the GDPR. Consumer rights, as stated in the GDPR – for example, the right to be forgotten – need to be addressed by the controller who might be identical to the role model's 'metered data responsible', who processes metering data, or the 'metered data administrator', who stores and distributes metering data, and who both may be different to the 'meter operator', who operates and maintains the meter. Those requirements cannot be met by a Blockchain per se, as data on the Blockchain is inherently immutable and eternal, and there is usually not one designated operating authority. However, in the observed use case, a responsible authority is available, as the energy community needs to be incorporated in a legal form. This legal person would most likely take over the controller role in terms of data protection law. The GDPR further contains two novel applicable concepts to foster compliance with data protection obligations:

- All new inventions shall be designed in a way that privacy is considered from the beginning and not as a subsequent add-on (Privacy by Design), a concept that shall be considered with the advent of energy communities and their new applications.

- An evaluation (Data protection impact assessment) to reduce the risks of misusing personal data must be conducted, especially if the processing operation is 'likely to result in a high risk to the rights and freedoms of natural persons'. The DPIA is 'a process designed to describe the processing, assess its necessity and proportionality and help manage the risks [...] resulting from the processing of personal data by assessing them and determining the measures to address them' [27]. In particular, the execution of a DPIA is appropriate if new technological solutions are used, if data processing is carried out on large scale or if automated processing leads to decisions that have a legal effect for natural persons [27]. All these criteria would be applicable to the utilization of Blockchain technology [6].

Smart contracts

Irrespective of the types of objects involved, trading is traditionally formalized by way of a contract between (at least) two parties. Required are declarations of intent, i.e., an agreement between those parties. Automatically executed contracts as intended by the described use case are often referred to as 'smart contracts'. They use software, programmed to act in a certain way, to execute transactions once determined conditions are met. The main differences between traditional and smart contracts are shown in Figure 5. For energy market use cases, this refers to the allocation of energy within a community, i.e., an agreement between a self-producer that sells excess energy, and a consumer having a current energy demand [28].

Blockchain also acts as a transparent and immutable archive of these transaction and allows for subsequent accounting. Smart contracts fall under 'automated decision making with legal or similar effects' according to the GDPR [24] and thus pose additional issues regarding data protection (e.g., reverse transactions) [21]. Utilizing smart contracts without having pre-determined prices and a fixed allocation of energy within the community makes P2P energy trading interesting. It is however not clear whether and how national regulations will support or allow innovative approaches such as auction-based allocations (e.g., [29]).

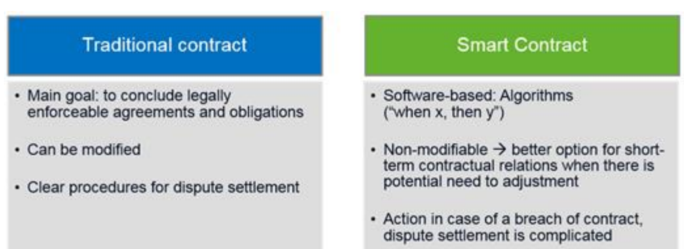

Figure 5: Main differences between traditional and smart contracts [10]

Conclusion

Current European energy policy is centered around integrating renewable energy sources and new technologies into the energy systems and markets, and making the consumer the cornerstone of these activities, both on local and global levels. The attainment of these objectives is expected to facilitate the energy transition as well as local value creation. Renewable energy communities, among others, can ensure active participation of consumers in covering their demand locally and potentially more efficiently, generate savings and value for themselves and the community, and as well support distribution networks through flexible consumption and generation. This study includes an overview of the relevant EU regulations and the draft of the Austrian national transposition act with a special emphasis on Blockchain use and P2P energy trading within energy communities.

Such communities and their broad spectrum of activities allow implementation of new innovative solutions, for example, by utilizing Blockchain that is likely to create value for all stakeholders involved through transparency and ease of accounting. However, Blockchain as a facilitating technology is not specifically mentioned in the current European regulatory framework. Blockchain as a distributed ledger on the one hand and its use in specific cases on the other hand need to be clearly distinguished: the treatment of Blockchain depends on its type and the specific application. In other words, it is not Blockchain per se that needs to be regulated but the specific applications that this technology supports [10]. As P2P trading has only recently been addressed – albeit to a very limited extent in the RED [4] – more questions arise as to the way it can be operationalized. These questions include the role of the DSO in enabling and allowing P2P energy trading as well as the data exchange between DSOs and energy communities. Blockchain technology facilitates P2P trading through so-called smart contracts. However, to effectively implement them, it must be considered how Blockchain-based P2P fits into the regulatory context and whether smart contracts can be treated on par with traditional contracts.

Enabling conditions for Blockchain technology may help to address some of the issues arising from the operation of energy communities and their use of the public grid. These aspects need to be further acknowledged in the regulatory framework. Introducing P2P trading into the directives can only be a first step, whereas many aspects regarding other legal areas that need to be considered remain unclear for the time being.

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