Peer to Peer technologies in energy network

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***Abstract*— Peer to peer trading can be a key element that will help in the transition to active management of electricity networks. This will increase network flexibility at optimal investment costs. Existing pilot projects with the expected results and clarification of the advantages and disadvantages are the subject of research in this article. Regulatory norms and the possibility of decentralized energy sources to provide an opportunity for transition to a low-carbon economy are considered.**

Keywords*— peer to peer, active energy management, electricity trading

I. INTRODUCTION

Electricity is a flexible and adaptable energy, but it is difficult to store, while customer consumption and the coincidence of demand are constantly changing. These requirements require continuous transmission and the availability of energy through a distribution Conventional energy markets or centralized energy supply involves electricity generation in large-scale at centralized facilities such as fossil fuel power plants and nuclear power plants[1-8]. These generation facilities are located far away from the consumers and the energy is transmitted via high voltage transmission lines managed by complex systems and intermediaries. This type of generation results in air, water and land pollution. With these problems in mind and the falling cost of renewables and improved electricity storage systems people are opting for clean energy. Decentralized or local power supply involves electricity generation in house or near a place where it will be used, from solar, wind and geothermal. They are generally managed locally by prosumers who produce electricity for their own consumption, selling excess to the grid. The large-scale systems are very small in number so an authority can easily manage these systems without security risks. The prosumers are large in number, therefore a digital platform to facilitate secure buying, selling, billing and auditing is necessary[9-20]. A peer-to-peer energy trading business model powered by blockchain helps in facilitating distributed energy systems.

Traditional markets, whether financial or electricity markets, are based on a trading pool mechanism, which means " Open market for buying and selling. Operators influence the price and quantity of shares, thus attracting additional participants" [21].The energy market differs from other markets in that each of the participants impacting the flexibility and management capabilities of the power system. This should be a major incentive for each participant for slowing down the impact of the sudden exit of a large number of consumers from the electricity grid which can have negative impact. There are various opportunities for participation in the energy market direct or indirect and feed in tariff as well, which have their advantages, but also their limitations, which can cause prosumer to leave the market [22]. At the same time Peer-to-peer uses transparent clearing mechanisms that give equal rights to all users, the ability to negotiate between each user and ensure the security of personal data, while also affecting the complexity and efficiency of the market [23].

II. DEFINITION FOR PEER TO PEER

Principle and structure of the energy distribution network are given on figure1.

In Collins English Dictionary [24] the definition for peer to peer is explained as "Two computers can directly exchange information without using a server as a connection between them." A peer to peer in fact is a network that allows participants to share the resources they have. In this way, participants reduce their investment costs while increasing the energy transferred, reducing peak loads and contributing to rising the volume of renewable energy systems and energy storage systems.

The context adopted by us, the peer-to-peer flexibility trading platform will allow energy market participants to take an active position by participating in local energy and service markets. The active participation of the participants connected in the energy system will allow to optimize the costs, to provide flexibility of the electricity transmission network and to provide financial income for both the consumers and the electricity distribution network operator.

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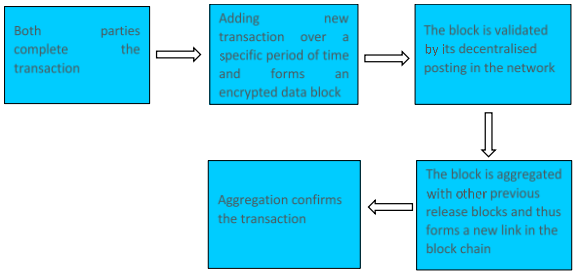

Fig. 1. The process of blockchain between two parties

The blockchain generates decentralized storage of encrypted data and allows transactions between two parties (peer to peer), without using a central structure for information processing. The process allows high results at lower costs, increased security, speed, authenticity and flexibility. Blockchain is characterized by improved interaction between the individual participants related to the traceability and irreversibility of the agreed terms. The five-step process of blockchain is given in Figure 1. This can be used as a good basis for proactive growth of the smart grid and for better interaction between the various participants in the energy market in a decentralized environment.

III. PEER TO PEER TECHNOLOGY AND BLOCKCHAIN BENEFIT AND CHALLENGES

The increase of the added value for the electricity distribution network can be realized through new business models, which will ensure the entry of new technologies for production and transmission and storage of electricity with transparent and competitive offers on the market, through financial incentives for all market participants, which contribute to increasing the flexibility of the energy system.
In order to easily make this transition to improving the flexibility of the electricity system and under fully transparent conditions, it is necessary for all participants to have real-time information on both consumption and production, as well as on the available storage options for electricity.

Despite the many advantages of peer to peer and blockchain, such as transparency and security, there are a number of challenges Fig.2. With the widespread penetration of peer to peer networks, both technically related to the upgrade of the electricity distribution network and legal related to the circulation of personal data, at the same time a number of economic difficulties exists, such as different geographical features in the distribution of consumers and producers of electrical energy. Not insignificant is the energy used to encrypt and transfer data between individual participants in the peer to peer network coupled with blockchain technology. Studies of the energy consumed for the bitcoin transaction show that the amount of energy needed is in the order of 275 kWh [25]. The same amount of energy should be expected when using this type of technology in decentralized electrical networks.

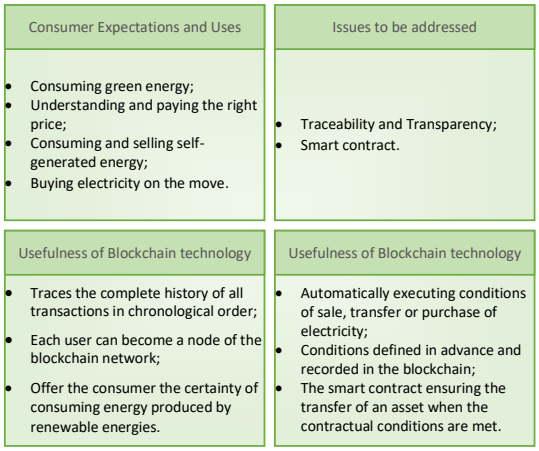

Fig. 2. Use cases of blockchain in the energy sector

Digitalized network operation

European Union defines digitalization as " The process of data transfer, their monitoring, analysis are used for the implementation and subsequent exploitation of assets by the participants in the energy system" The digitalisation of the energy sector makes it possible to make the connection between the individual actors in the energy system, such as markets and services that would not otherwise be possible [26]. To improve flexibility, digitalisation is needed throughout the system, from generation level to customer relationship level. [27]. The International Energy Agency's analysis shows that in the 1970s, electricity distribution companies were the first to use digital technologies to optimize the operation of electrical networks, and that today almost all electronic devices are connected to communication networks to provide many additional ancillary services through various applications. These include personal healthcare, smart grids, surveillance, home automation and smart transport [28].

The operation of the distribution network is related to the management of many and complex processes (Figure 3). It is necessary to upgrade the existing infrastructure and all participants connected to the energy system to become part of the new digitalization to ensure a reliable transition to digital management of electricity distribution networks. There is already experience in the management of digital distribution network management systems, both in a number of demonstration projects and in a number of electricity transmission networks around the world. Of course, this digitalization and the new business models must also be seen as a new consumer of electricity, which is comparable to the electricity consumption of a Western European country.

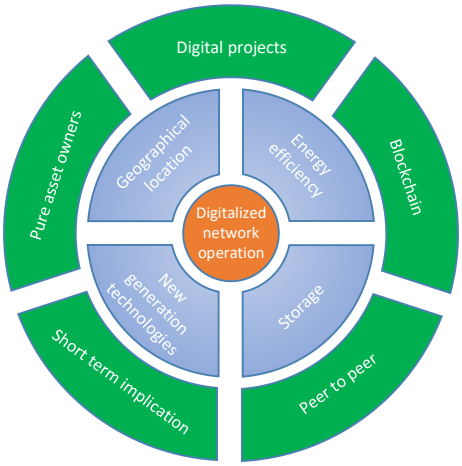

Fig. 3. Structure of Digital network operation

Studies of similar blockchain initiatives

There are different examples of project related to the possibilities that blockchain can provide in energy sector. Some of more contributing ones are summarized in Table I according to The European association of cities in energy transition [29].

TABLE I.

Blockchain projects	Based on and aim	Induced innovation
Solution Sunchain *"closed" blockchain with a limited number of actors*	Solar electricity in social housing and housing estates; Solar electricity on nearby separate buildings; Solar electricity for recharging electric vehicles (roaming). The production of the solar installations and the electricity consumptions of the participants to be encrypted, signed, and recorded in a blockchain.	Certified transactions; Traceability of the solar kWh and the possibility to invoice the housing for its real share; Automatic transfer to network manager software; Cost accounting – dashboard; Facilitate the integration of solar energy in the municipal heritage with various uses
DAISEE *semi-public company the municipality (60%); the municipal electricity board (20%) and a collective of citizens (20%).*	Connection and facilitate the crossroads between actors of the territory; to be a producer of knowledge and know-how to snowball elsewhere, in other territories; first and foremost to empower people to make. The aim is to accompany a territory in its quest for energy autonomy by using blockchain technology	Hardware; Software (Ethereum and other technologies allowing a distributed, secure, transparent system); Network infrastructure and governance
I-NUK *Start up*	The emissions of its users; works with small solar energy producers (including local authorities) in France and internationally (installations between 200-300 KWh) to help them better monetize their produced energy. The aim is to reform the carbon credit system, by creating a blockchain application to allow each individual to easily offset their daily carbon emissions, and to reinvest these offsets in the construction of new solar power plants.	By relying on the Ethereum blockchain and its smart contracts, make the certification process transparent, efficient, secure and automated. A permanent audit and publicly verifies that the certification process applied is correct. Includes the energy consumption induced by the use of Ethereum in the carbon offset, thus ensuring the carbon neutrality of its approach. The model allows small solar energy producers to make better use of the energy they produce and thus promote the development of clean and local energy.
KLENERGY TECH *Start up*	Pylon Network proposes to use Blockchain technology to facilitate the knowledge of flows for energy vendors. The product is aimed at renewable energy cooperatives. The renewable energy community can play on demand and optimize flows in real time	Transparency of flows; Reliability and security; Accessible to all; Low-energy server running on surplus renewable energy.
Tal.Markt *municipal energy supplier for the city of Wuppertal*	Creates a local and regional market for renewable energy produced in Wuppertal. The aim is to connect local renewable energy producers with citizens, especially the 5000 wind turbines that will no longer be supported by subsidies after 2020	Flexible and transparent, and allows citizens to follow in real time the volume of renewable energy produced and to know which local supplier it comes from. The guarantee of origin of the renewable energy is ensured by the infallibility of the blockchain; Obtain a new form of income, but also to support local producers who will no longer be able to count on the support of the German Renewable Energy Act (Erneuerbare Energien Gesetz) after 2020; If there is a lack of renewable energy (e.g. because there is little wind or no sun), the WSW ensures security of supply; Allows investors to form a large enough group of citizens to encourage the construction of new wind turbines or solar plants, outside of the support of the Erneuerbare Energien Gesetz.
Gruenstromjeton *Public company*	Regionally produced renewable electricity and wants to target families in particular; The aim is to offer its clients a new service to encourage them to use more renewable energy.	Citizens are encouraged to consume more renewable energy in their energy mix and thus not only promote the development of renewables in the territory, but also benefit from it themselves; The SEV takes advantage of the block chain to reduce transaction costs (smart contracts) and the costs of billing processes, among other things; Since the architecture of the blockchain is Open Source, the SEV does not have to pay any license fees.
NRGoin *University project*	The idea behind NRGCoin is to respond to the inadequate (not flexible enough) subsidy of renewable energy and to encourage citizens to consume local renewable energy by paying them with the NRGcoin cryptomoney	By using the Ethereum blockchain, NRGcoin benefits from the advantages of this blockchain (disintermediation, transparency, decentralisation, reliability and indelibility). In addition, NRGcoin wants to add value to the renewable energy installations of these
Brooklyn microgrid *Private company*	Solar panels installed on the roofs of five residential buildings produce electricity, the surplus of which is sold to neighbours. These buildings are connected to a conventional grid whose transactions are managed and stored via a block chain. One of the objectives of the project is to create a local renewable energy community. 130 new households have expressed an interest in joining such a network.	Peer to peer; Smart contracts and payments technology through a virtual currency (Ether); A "community and shared energy market", with surplus electricity being exchanged between neighbours through secure transactions.
SolarCoin *International company*	Any owner of a photovoltaic installation can participate in the grid. promote renewable energy by allowing all solar energy producers to obtain a remuneration depending on the amount of energy produced. Solar energy producers can claim 1 SolarCoin for every 1 MWh produced and fed into the grid.	Low energy consumption; Reduces the amortisation period of the solar system; An evolution desired by the initiators: The recognition of this currency by the local authorities

[a.] Pilot blockchain projects

Although there are various studies, there is still a lack of a full overview of blockchain trading schemes for energy sources, as well as a clear classification according to the challenges facing the electricity system. The presented blockchain-based energy scheme and applications have their advantages, but still do not ensure full equality of the various actors and do not take into account many important factors important for balancing the electricity system, such as the geographical location of both consumers and electricity producers.

IV. Conclusion

The traditional design of the energy system, generation, transmission, distribution, consumption is associated with many costs, both investment and technical. Reducing fossil fuels and climate change, using new energy storage technologies, electromobility, as well as the need for clarity

in the pricing process require the use of new technologies to allow this to happen in a balanced and symbiotic way.

Three main trends that can cause challenges in the future distribution networks are increasing penetration level of stochastic renewable energy sources (RES), electrification of many other fields as hating and transport, and a more coordinated control of distributed energy resources (DERs) that can increase the load concurrency, potentially lead to congestions and voltage limit violations in the distribution networks.

A peer to peer market design for electricity markets is an option when millions of flexibility assets are at the DSO network. Thanks to applicable concept from Blockchain for the peer-to-peer flexibility market, we have overviewed existing initiatives, identified their innovative aspects and considered in the context for future energy projects.

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