CONCEPT NOTE

Electricity trading on a distributed ledger

Introduction

Universal access to energy is crucial to almost every major challenge and opportunity the world faces today – health, education, food security, employment and climate change, to name a few. Therefore it is explicitly recognised as a key enabler for development in the Sustainable Development Goals, namely in SDG 7, ‘Affordable and Clean Energy’. Technological advancements will play a decisive role in achieving the Global Goals, e.g. improve energy efficiency, promote renewable electricity generation, and increase access to modern energy services.

The necessity for action becomes obvious when looking at some global key figures regarding energy: currently, around 14% of the world's population have no access to electricity – more than 50% in Sub-Saharan Africa alone – and about three billion people still rely on polluting combustibles such as wood and coal for heating and cooking.[10]

The current energy systems have a long lasting legacy to overcome. For decades, fossil fuels such as coal, oil or gas have been major sources of electricity generation. They resulted in highly centralised energy systems focused on large generation plants using high-voltage power grids to distribute electricity. While legacy grid infrastructure remains highly centralised today in many economies, two mutually reinforcing trends are pushing towards decentralisation: increasing use of renewable energy and digitalisation. With increasing variable generation from sources such as wind and solar power feeding into the grid, new needs for flexibilisation are in demand, e.g. improved battery storage, predictive analytics, smarter grids or demand side management. Planning, connecting or hooking up new electricity generators to existing grids becomes more complex. This is where digital technologies such as blockchains, data analytics or artificial intelligence might play a key role.

In countries with low levels of electricity access, both on-grid (traditional power lines) and off-grid solutions (mini and micro grids) are crucial for achieving universal access. This development is supported by decreasing costs for renewable energy technologies such as photovoltaic (PV), and a focus on energy efficiency measures that can help countries extend access to energy for their populations. However, all measures need to be backed by an enabling environment with the right policies, regulations, and financial incentives.

Problem description

We will focus on the potential the technology has in creating new markets for electricity trading: peer-to-peer (off-grid microgrids or with distribution grid access) as well as wholesale trading (grid access). The selection is based on two findings. On the one hand, there are the first pilots being conducted in this area. On the other hand, the value chain ‘retail in the energy sector’ tends to offer the simplest conditions for implementation with, at the same time, presumably high added value in the development context. Current examples include wholesale markets between generators and retailers such as the German Enerchain consortium with its 50 European utility members, or between individual households such as in the Sukhumvit neighborhood in Bangkok or the Brooklyn Microgrid in New York. Even in areas that remain disconnected from distribution grids, neighbours with solar rooftop PV systems, improvised grids and smart meters can start trading with each other on a peer-to-peer basis, as demonstrated by the start-up Solshare in Bangladesh.

Electricity markets on Blockchains

A well-functioning energy system is dependent on data being shared correctly, quickly and uniquely with the relevant actors within the system. Therefore it is crucial how large data streams from decentralised feed-in, smart metering or grid operation can be managed. Blockchains promise a more efficient and resilient IT-infrastructure in comparison to existing systems to manage aforementioned data in distributed electricity systems, while allowing for a new level of transparency, tamper resistance and security.

The above advantages of blockchains may open up considerable potential in electricity trading. As mentioned, we think in terms of two models. One model would make it possible to enable exchanges for wholesale electricity trading on a blockchain basis. This can be interesting, for example, in contexts where cross-border electricity trading is to take place and one wants to trust the technology rather than a state authority – if existing – to record and pay for the quantities of electricity. The other model is based on the assumption of a microgrid. In this off-grid system, the blockchain should allow energy trading between participants connected within the microgrid.

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Blockchains can function as a shared information and transaction platform for all market participants. Electricity generation and real-time demand are recorded on the blockchain by using Internet-enabled smart meters, while the transactions between the participants are executed and documented automatically on the blockchain. Blockchain's ability to make even the smallest data transactions economically viable ultimately entails new degrees of participation and incentives.

Electricity marketplaces are heavily dependent on data integrity. Therefore, one part of the solution needs to collect data streams from decentralised electricity feed-in. Validity of this data is best ensured by using tamper-proof cryptography-enabled hardware as well as an algorithm cross-checking various data sources against each other. Based on such validated data sources, a blockchain-based electricity marketplace cannot only unite the demand and supply side for energy purchases, but also immediately settle the transactions, including monitoring the delivery of electricity and processing of corresponding payments. Smart contracts can ensure that electricity is requested, for example, when prices fall below a price threshold or when green electricity or local power is available.

In general, in order for electricity markets to work efficiently, they should have a low entry barrier, be accountable, transparent, and have low transaction costs. Current mostly centralised electricity marketplaces often have high entry barriers due to, for instance, thequantity of power to be traded, a lengthy registration process and technical accessibility. As a result, overall operational transaction costs for electricity retailers are high, even if the actual transaction fees might be low. As a neutral and comparably cheap IT backbone, DLT helps creating a marketplace with an increased number of participants.

Leveraging decentralization

DLT solutions have several advantages compared to traditional electricity marketplaces. As described above, they might lower market entry barriers for participants, thus allowing and incentivising new actors to partake in electricity trading. Blockchain-assisted trading could create new incentives to invest in and operate renewable electricity generation by providing a highly automated and yet secure way to buy and sell electricity. Blockchain technology promises direct, anonymous trading of various electricity products (e.g. day-ahead, spot market) without the need to involve a 'physical' electricity exchange or intermediary as it enables trustworthy transactions between players who do not know or trust each other. Furthermore, such trading systems might lower the need for ancillary services since price signals can be implemented that secure the stability of the grid. Thereby, particularly in countries that do not yet have energy trading systems or exchanges, completely new markets could be created and far-reaching investments could be achieved. The consequences for the consumer would be greater security of supply, but also the possibility of incentivising own renewable electricity generation and directly benefiting from their investments.

In this context, we have to note that most projects are currently at an early stage with limited maturity. Although many blockchain applications may add different values to electricity systems, there are few projects that serve as proof thereof. In the context of development cooperation it is therefore vital to understand that the only way to show the actual added value of the technology is through implementing and evaluating small-scale pilots.

Potential challenges

The prerequisite for blockchain-based marketplaces is that the participating electricity generators are equipped with smart meters that communicate via the Internet. They provide accurate data on the quantity and price of the power to be traded. The information about these specifications is secured on a blockchain. Therefore, marketplace models cannot be implemented without digital hardware that bears the corresponding costs.

Although the prices for renewable energy are decreasing and become competitive, or even cheaper than fossil fuels in some countries, the centralising legacy of the latter remains. As mentioned above, the majority of electricity systems globally are still based on fossil fuels today. The switch to renewable energies and the associated costs, which will lead to more fragmented competition for electricity trading and allow for marketplaces involving several actors from the start, is therefore an essential factor.

Even if renewable energy generation is to be found in a country and its level of digitisation is sufficient, especially smart meter penetration, state and regulatory authorities remain of enormous importance. Energy systems are often heavily regulated by the state or, in some cases, controlled by a state-owned corporation. Therefore, electricity trading – be it in wholesale markets or on a peer-to-peer basis in microgrids – might not be covered by a legal framework and therefore not implemented.

Finally, the existing and planned grid infrastructure remains of high importance – even in off-grid microgrids. Investment costs in this infrastructure are generally high and even with the result of creating a new market, the return on investment might not be secure.

Ideal application context

An optimal implementation environment is first and foremost dependent on the regulatory landscape of the country at hand. Looking at energy trading on a distributed ledger, it will require a context with a sufficient degree of liberalisation that allows various actors to trade electricity in the first place. Wholesale markets tend to be more liberalised than retail markets – as regulators often shield private households from price signals.

Since high potentials are to be expected in both cases, also for the regulator, a regulatory adjustment cannot be ruled out. However, this would take a correspondingly long time. Regulatory sandboxes (i.e. 'live-like' testing environments set up by the regulator to allow innovators to test their products and business models without following some or all usually applicable legal requirements) would be an attractive alternative that would make it possible to test the cases. In these locally and temporarily restricted frameworks, suitable cases could be tested with blockchains.

On the technical level, reliable data sources need to be available. This is more often the case in network operations than at retail level. Pilot projects could start with rolling out blockchain-enabled smart meters which would likewise work in rural off-grid locations, with communication links established by wire or through Wifi or low-power wide-area networks (LPWAN).

Current initiatives

Projects worth looking at include:

- Energía Abierta – open energy-grid data platform in Chile
- ME SOLshare – peer to peer electricity trading in rural microgrids
- Brooklyn Microgrid – peer to peer trading of renewable energy in Brooklyn, New York
- Enerchain – Consortium blockchain for wholesale electricity and gas trading
- Energy Web Foundation – blockchain solutions for grid operations and certification of green electricity generation

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