THE BLOCKCHAIN TECHNOLOGY AS A NECESSARY TOOL BETWEEN CONTRACTUAL RELATIONSHIPS

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Abstract

The article presents objective argumentation of using the blockchain technology which is expected to become a core factor for future interrelations between companies and individuals. Whereas, there are lots of economists who still manifest skeptical view for blockchain technology to rely on. Nevertheless, involving more and more links in a whole supply chain creates a progressive growth in popularization of decentralized web-technology throughout whatever economies irreversibly. The bitcoin as the main product of blockchain technology has already been proving it year by year. Not only crypto currency but also concept of smart contract will contribute in future contractual relationships as a matter of trust.

Under the circumstances of mistrustful foreign currency, banks or mediators, the fear factor for cooperation all over the world will get much reduced as well as chances to be involved in unfair cooperation and interdependency. The aim of this paper is to present a basis of how blockchain technology works and give vivid examples of some sectors which have already succeeded in real practice essentially. Some assumptions and evidence in figures will be found. Also, there exist some barriers and difficulties for mass invention of this technology in common practice but certainly these obstacles will be inevitably eliminated over time.

The technology itself is under constant developing and those investing in developing information systems today will definitely gain tenfold back tomorrow.

Keywords: blockchain technology, electricity price, fair trade practice, smart contract, supply chain

JEL Classification: L14, O31, D86, F23.
1 Introduction

The term "blockchain technology" typically refers to the transparent, trustless, publicly accessible ledger that allows us to securely transfer the ownership of units of value using public key encryption and proof of work methods. The technology uses decentralized consensus to maintain the network, which means it is not centrally controlled by any company (https://www.blockchain.com/, 2018).

The technology is hard to imagine but as everything genius works simple. The information about any transaction or action records to simple digital block and then any further records are being added to the previous blocks that develops a holistic chain of blocks are recorded chronologically and publicly. All blocks are spread out between computer’s net, and called chained blocks or as widely known - blockchain.

The most famous product of that technology is cryptocurrency the Bitcoin. As a result, the distributed continuous blocks which are being checked themselves between each other are almost impossible to re-record, to change, to steal or damage the information after the data has been accepted by all computers involved in the net. This is the biggest advantage of the technology and someone has called it ‘the technology of truth’. Blockchain technology can also be applied to other types of uses. It can, for example, create an environment for digital contracts and peer-to-peer non-digital asset sharing like electricity power in energy supply chains.

Traditional intermediaries are no longer required in this model, as the other participants in the network act as witnesses to each transaction carried out between a provider and a customer, and as such can afterwards also provide confirmation of the details of a transaction, because all relevant information is distributed to the network and stored locally on the computers of all participants. This case we will try to look deeper in electricity market and make some assumptions on how potentially it is able to lead to whatever better effectiveness of functioning.

The blockchain acts by different way destroying centralized control of some energy serving companies and might allow the transactions are being processed in accordance with automotive electronic scripts, which execution will be ensured by the net itself. These contracts might include any terms, any objects and acts which are preliminarily agreed between participated parts. The difference is that all these terms and acts are agreed in an electronic form and without any intermediate between counterparts of agreement. As a result we can expect that meter operators, bank infrastructures, energy operating companies likely to disappear from energy supplying markets, as well as high service fees of middlemen. Although it is true that the blockchain net consumes some energy and resources but relatively far less than energy consumption and fees in existing models.
In the paper, we will present the functioning of electricity market as this is the most potentially prospective sector in blockchain technology among non-digital assets and try to find some evidences that blockchain is the necessary tool not only for that particular sector of the economy but potentially lucrative for the other markets in general and society as a whole. The market data is presented and projected on the example of the Slovak Republic.

2 Data and Methods

2.1 Digital algorithm of contract as element of trust

Due to the blockchain system is fully decentralised where all transactions being shared, executed and performed simultaneously in consequent chain it makes this technology potentially disruptive.

Nowadays, all participants realize obvious advantages of smart-contract application that runs and executes according to preliminary programmed script that corresponds to contract’s agreement. Reduction of transaction costs as a result is the opportunity for even a small and weak company to get into a global market and make its presence beyond local territory with the help of smart-contract technology. Absolute trust between counterparts is not the only one that forces enterprises carefully study opportunities to invent smart-contracts in their activity. The IBM Blockchain resource [16] defines the benefits of supply chain with blockchain as:

- Reduce or eliminate fraud and errors;
- Increase customer and partner trust;
- Reduce delays of paperwork;
- Improve inventory management;
- Identify issues faster;
- Minimize courier costs.

2.2 Ecosystem of existence

In order to follow a contract by means of automation the contract should be in constant coordination with a real practice of agreement. For that, the smart contract gets the information from different digital sources such as indicators, sensors, devices and any other systems which are able to record and transmit an important data for each stages implementation of the contract.
Figure 1 *Cornerstones of a decentralized energy - transaction and supply system*

![Components of a blockchain-based system](image)

Source: www.pwc.com.

One of the brightest examples of such tuned smart system that involves peer-to-peer (P2P) energy distribution has already practically implemented in New York. According to www.brooklynmicrogrid.com (2016) [21], since April 2016, a pilot project run in Brooklyn has been discovering how to integrate buildings connected with distributed renewable energy resource systems such as solar panels in a decentralized peer-to-peer power grid. The rooftop photovoltaic systems installed on five of the buildings participating in the neighborhood project generate solar energy. The buildings do not consume themselves all energy generated but partially sold surplus of electricity to five other neighboring households. All buildings are interconnected through the conventional power grid, with transactions being managed, executed and recorded in the blockchain system. This example shows that local energy supplying system can successfully work autonomously within peer-to-peer territory with perspective to be grown.

Implementation of the project requires both smart meter technology and blockchain software with integrated smart contract functionality: smart meters are needed to record the quantity of energy produced, blockchain software is needed to effect transactions between the neighbors, and smart contracts are needed to carry out and record these transactions automatically and securely [2].

In the future, it is planned that the system can be controlled by means of an app that could be used to specify certain parameters, for example exact prices for electricity is to be sold among the neighbors. All transactions are then going to be executed fully automatically according to pre-agreed rules.

This approach are also mentioned (by Sun J., Yan J., Kem Z., Zhang K. 2016) [14] in describing the concept of blockchain-based sharing services what contributes into smart cities development.

**Comparison of work models**

Blockchain has the potential to change the way we arrange, record and verify transactions, with avoiding to rely on intermediaries (exchanges, trading platforms, trade and metering energy companies) towards decentralised business models where producers and energy consumers interacting directly. In fact, unlike the
financial and digital asset markets, the energy sector has a huge potential faster to be transformed on blockchain and take determinative role in ‘things’. [3]

Figure 2 The general concept of economic interactions in centralized and de-centralized electricity markets

Source: www.pwc.com.

Because of these significant differences in concept there is being modified internal processes within electricity supply chains as well.

Figure 3 The difference in electricity supply chains

Source: www.pwc.com.

3 Results and Discussion

The aim of this paper is to give a comprehensive overview of the current stage of use the blockchain technology, to present a basis of how blockchain technology
practically works and to give a vivid example of electricity sector which is the most potential in IoT (internet of things) for intensive developing [20]. To achieve this aim we bring a comparison of work models used up to day and present a case study of electricity supply chain in the Slovak Republic.

Practically, there is compared price forming policy for electricity per kWh in existing way and possible theoretical approach to form it in terms of alternative functioning the market in blockchain environment.

3.1 Electricity market price establishing

Market power refers to the ability of a market participant to raise prices profitably above competitive levels and lobby those raised prices for a significant time. Market power can exist in two forms - vertical and horizontal. Vertical market power can exist where a party controls two related products or services. In the electric power industry, a party that controls both electricity generation and transmission has the potential to seize vertical market power. An owner of generation has a financial incentive to exercise market power and manipulate prices directly related to the quantity of power sold into the market [8]. The power generation market is highly concentrated in Slovakia. The largest power generating company (Slovenské elektrárne) had a market share of 78.9% in 2011 [12] that is definitely considered as highly monopolized market.

There are two major market models: electricity pools and bilateral transactions. In Slovakia, trading takes place mostly through bilateral contracts. 10% of total annual power production in Slovakia has been traded on short term day-ahead exchange platforms [11].

A pool, or market exchange, involves basically a specific form of auction, where participants send bids to sell and buy electricity, for a certain period of time, to a market operator, who in turn analyzes the bids and calculates a market price that must be followed by all participants. In turn, bilateral contracts consist of essentially in direct negotiations around energy prices, volumes, time of delivery, duration, among other possible issues, between two traders. In terms of smart-contracts the set prices are very flexible since the negotiating parties can specify their own contract terms. Under mentioned terms, a power provider charges a price that is much higher than production costs, meanwhile buyers overpay for steady high price but stable by bearing all potential risk in electricity deliveries anyway. For example, Slovakia suffers from unscheduled electricity loop flows from Germany, threatening the secure grid operation and cross-border wholesale trade. Therefore, final consumers take also these risks their own.

Conceptually, a multi-agent system presents itself as a good way to interact between the members in order to ensure better energy security as a whole, to cut
transportation losses, to be able reinvest obtained incomes, saved from taxes and middlemen, to energy efficient local productions and developing territories.

The numbers of consumers switching power providers are increasing every year, which is a good sign for energy market liberalization. According to RONI (Regulatory Office for Network Industries in the Slovak Republic), switching was not beneficial in every case, as some power suppliers failed to set prices in a transparent manner. Irregularities related mostly to invoicing issues.

The picture with decentralized system under blockchain technology among generating power units has different working approach. For example, electricity power capacities communicate with computing electronic platform. In that model, market participants can submit offers to buy energy, or bids to sell energy, directly in a computerized marketplace. When a new bid is submitted, the software checks to see if there is a matching offer for the bid’s period of delivery. In positive case, a deal automatically performs both the price and quantity are displayed to all participants. If no match is found, the new bid is added to the list of outstanding bids and remains there until a matching offer is made, the bid is withdrawn, or it lapses.

### 3.2 Transmission and distribution

The role performed by meter operators would change: they would no longer have to collect and record data themselves, as all consumption and transaction data would be exchanged automatically and accurately through blockchain technology (smart contracts). Such systems of smart metering in Slovakia are still being discussed. Distribution system operators install smart meters on a voluntary basis and usually it is about energy-intensive customers.

Horizontal market power occurs when a party controls a significant share of the market for a particular product [1]. The key players in face of wholesale and retail energy companies will be forced to leave the mediation function due to sharply reduced need. The number of licensed power retailers in the whole retail market has been constantly growing and it reached more than 400, also around 20 retailers provide electricity to household consumers [7]. Despite the growing number of competitors in the power supply market, prices for household consumers, small and medium companies remain strictly regulated.

The physical electricity controlled by the contract would continue to flow to the end user directly from the closest generator. Blockchain technology allows for direct contractual relationships to be established between energy consumers and energy producers. According to data, the Slovak Republic transits 9 622 539 mWh a year, where transit losses are 48 795 mWh, in turn cost of losses (tariff prescribed by regulatory agencies regulating) is 55,96 (Euro/mWh) that leads to overall losses around 2,73 bln.euro per year. (Energy Charter Secretariat, 2014).
Plus, to this numbers it is required to sum losses from solely domestic routes within points of production and consuming.

**Table 2** The structure of final electricity prices for households (VAT excl.).

<table>
<thead>
<tr>
<th>#</th>
<th>Type of payment</th>
<th>€/mWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Commodity price</td>
<td>30-65</td>
</tr>
<tr>
<td>2.</td>
<td>Fixed payment per client</td>
<td>0.65</td>
</tr>
<tr>
<td>3.</td>
<td>Fixed payment for connection to the grid</td>
<td>4.25*</td>
</tr>
<tr>
<td>4.</td>
<td>Distribution tariff</td>
<td>22*</td>
</tr>
<tr>
<td>5.</td>
<td>Tariff for losses (physical loss in grid)</td>
<td>8.3</td>
</tr>
<tr>
<td>6.</td>
<td>Tariff for system services (Voltage/frequency stability)</td>
<td>7.7</td>
</tr>
<tr>
<td>7.</td>
<td>Tariff for system operation</td>
<td>21.8</td>
</tr>
</tbody>
</table>

*- average in the range

Source: ENEL and ZSE, 2015.

Besides these 9 components, at company’s electricity bill appears an additional item - "execution duty".

### 3.3 System fees

**Table 3** The structure in price forming for non-households in mWh

<table>
<thead>
<tr>
<th>Price structure per mWh</th>
<th>€/mWh</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>27.09</td>
<td>16.7</td>
</tr>
<tr>
<td>Cost of electricity gener., trans.&amp; distrib.</td>
<td>108.72</td>
<td>67</td>
</tr>
<tr>
<td>Electricity tax:</td>
<td><strong>26.45</strong></td>
<td><strong>16.3</strong></td>
</tr>
<tr>
<td>Renewable subsidies</td>
<td>14.4</td>
<td>8.87</td>
</tr>
<tr>
<td>Cogeneration subsidies</td>
<td>2.8</td>
<td>1.72</td>
</tr>
<tr>
<td>Lignite mining subsidies</td>
<td>4.4</td>
<td>2.71</td>
</tr>
<tr>
<td>National Nuclear Fund contribution</td>
<td>3.2</td>
<td>1.97</td>
</tr>
<tr>
<td>Excise duty</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Grid operator dividend</td>
<td>1.15</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Source: http://iness.sk/ [17], modified by the authors.

There are revealed the aggregated content of electricity tax in the table above. Further, there is presented an each duty description in order to get clearer view...
of the meaning each of them, and find a possible way to shorter these obligations due to relevant processes in a blockchain-based system.

**Subsidies for renewables and co-generation** – these subsidies are hidden under the term “system operation”, they do not have much to do with that. These costs of environmental policy are not necessary for commercial operation of production, transmission and distribution of electricity.

**Subsidies on domestic lignite power generation** – these subsidies are used for keeping approximately 4,000 jobs in mines in central Slovakia that supply economically inefficient thermal power plant in Nováky [17]. It also constitutes a social policy and does not relate to electricity market operation.

**National Nuclear Fund contribution (NNF)** – The NNF collects funds for current nuclear power plants and any future decommissioning. In fact, it is paid by all customers for each consumed MWh regardless of whether it comes from photovoltaic cell or hydroelectric power plant and as a result it is paradoxically that renewable sources sponsor nuclear power generating and not on the contrary.

**Excise duty**– excise duty is the result of the EU’s effort to transfer tax burden from labor to consumption and at the same time to create pressure to slow down the growth of electricity consumption. Slovak government introduced the tax without cutting down labor taxes and levies. Additionally, the tax administration costs and revenues are literally cancelling each other.

**“Dividend” of SEPS** – As the “natural” dividends of energy enterprises are not co-owned by the state directly but it is made artificially to increase profits of the controlled companies. As it is known, the grid operator SEPS, which administrates high-voltage network, is 100-percent owned by the state. Considering the average annual consumption of 28,500,000 MWh, consumers pay €1.15/MWh to the state as a “dividend” for each consumed MWh of electricity. If the state has not requested dividends from SEPS, it could lower the cost of the network operation.

### 3.4 Economic savings

In accordance with the information taken in sources and developed, it is possible to display the cost parts in a price with its shares in proper percent.

Table 4 *The composition of the typical electricity price per mWh on the market of Slovakia.*

<table>
<thead>
<tr>
<th>#</th>
<th>Costs</th>
<th>Euro per mWh</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Commodity price</td>
<td>44.02</td>
<td>27.13</td>
</tr>
<tr>
<td>2</td>
<td>Distribution</td>
<td>64.7</td>
<td>39.87</td>
</tr>
<tr>
<td>3</td>
<td>System fees</td>
<td>26.45</td>
<td>16.3</td>
</tr>
<tr>
<td>#</td>
<td>Costs</td>
<td>Euro per mWh</td>
<td>%</td>
</tr>
<tr>
<td>----</td>
<td>----------------</td>
<td>--------------</td>
<td>-----</td>
</tr>
<tr>
<td>4</td>
<td>VAT</td>
<td>27.09</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>162.26</td>
<td>100</td>
</tr>
</tbody>
</table>

*Source*: Developed by the authors.

Under certain circumstances, in particularly, using the blockchain technology in electricity market supply chain there is a place for elimination of some levies, taxes and fees in case of multi-agent market. In considered models, there is proposed not to look at basic price forming part as "Commodity price" in both cases and agreed to take it by ceteris paribus.

Diagram 1: The composition of typical electricity price in SR

![Composition of typical electricity price in SR](image)

*Source*: the diagram formed according to *Table 4*.

**Table 5** Distribution fees which are potentially to be reduced or even canceled

<table>
<thead>
<tr>
<th>Type of payment</th>
<th>€/mWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution tariff (Transit)</td>
<td>22*</td>
</tr>
<tr>
<td>Tariff for losses (physical loss in grid)</td>
<td>8.3</td>
</tr>
<tr>
<td>Tariff for system services (Voltage/frequency stability)</td>
<td>7.7</td>
</tr>
<tr>
<td>Tariff for system operation</td>
<td>21.8</td>
</tr>
</tbody>
</table>

*Source*: Assumed by the authors.

These tariffs might be transferred to the zone of responsibility of independent power producer and are not included in direct electricity cost for consumers. Those sums are considered to be accounted by individual generating power unity and redistributed within household activity. The next mandatory fees under control of the state could be cancelled in accordance with supporting private power producers and included by electricity generated unity itself for reinvestments.
Table 6 The following taxes are expected to be revised.

<table>
<thead>
<tr>
<th>Type of payment</th>
<th>€/mWh</th>
<th>% of total price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable subsidies</td>
<td>14.4</td>
<td>8.87</td>
</tr>
<tr>
<td>Cogeneration subsidies</td>
<td>2.8</td>
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<td>Grid operator dividend</td>
<td>1.15</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Source: Assumed by the authors.

In case of peer-to-peer transaction and terms of everything being equal the VAT-tax (20% in SR) as well as electric tax theoretically might be not included in mutual settlements. However, it depends on legislative regulations and state policy but nevertheless that is a ground to revise it in favor of power generating unit, in particularly and renewable energy policy in general.

Totally calculating theoretical benefits from using blockchain technology, we are able to potentially save costs. These saving are not supposed to be reflected in final price only whereas it might be re-distributed effectively through active contributors of green energy households among the country.

Let cost for generating is constant in cases with both B2B/C and P2P transactions, and Distribution tariff (transit) is invariable only in B2B/C chain, then:

\[
\text{PRICE potential mWh(B2B / C)} = \left( PrP + PrD \text{ potential} + SF \text{ potential} \right) \times 1.2 (\text{VAT}) =
\]

\[
= (44.02 + (64.7 - 8.3 - 7.7 - 21.8) + 0) \times 1.2 = 85.10 \text{ euro / mWh} \quad (1)
\]

Where:

- \( PrP \) – Price of production, %
- \( PrD \) - Price of distribution including retail margin, deviations etc., %
- \( SF \) – System fees, %
- \( \text{Coefficient (VAT)} \) – 20% of Value Added Tax in SR
- \( B2B/C \) – B2B and B2C transactions

\[
\Delta \text{PRICE, }\% (B2B / C) = 100\% - \frac{\text{PRICE potential mWh, B2B(C)}}{\text{PRICE current mWh, B2B(C)}} \times 100\% \quad (2)
\]

thus

\[
\Delta \text{PRICE, }\% = 100\% - 52.45 = \mathbf{47.55}\% \quad (3)
\]
Equally

\[
PRICE_{potential \ mWh(P2P)} = (PrP + PrD_{potential} + SF_{potential}) =
\]
\[
= 44.2 + (64.7 - 22 - 8.3 - 7.7 - 21.8) + 0 = 48.92\text{euro} / \text{mWh} \ (4)
\]

Where

\(P2P\) – transaction between individual households also known as peer-to-peer transaction

Therefore

\[
\Delta PRICE,\% (P2P) = 100\% - \frac{PRICE_{potential \ mWh, P2P}}{PRICE_{current \ mWh, B2B(C)}} \times 100\% = 100\% - 30.15\% = 69.85\% \ (5)
\]

It shows, that the current price for electricity might be potentially reduced by \textbf{69.85\%} or redistributed fairly among separate electricity individual producers and local micro grids they exploit in terms of using the blockchain technology and smart meters.

Properly, the price for mWh could also be lower by \textbf{47.55\%} for non-households.

Our results coincide with some expert’s opinions in the sector. For example, according to INESS (2015) [17], the electric tax elimination would reduce the price of electricity by more than €26 per MWh and therefore help to increase the competitiveness of the Slovak economy and increase the transparency of various policy costs.

4 Conclusion

As any other perspective technology it faces some basic reasons that do not allow growing too intensive in a business world. There are the basic ones which they meet in major cases:

- The public blockchain ecosystem allows anyone who wants to gain access to transactions on smart contracts in major are not acceptable to the business. After all, usually organizations are not willing to reveal their business connections, and even less are willing to open access to all their transactions.
- One another main obstacle remains a high entry fee. The programming of smart contracts is very expensive, and requires the presence of so-called code lawyers - specialists with a very rare combination of competencies.
- Putting metering digital indicators at each stage of contract procedure. That is exactly what is meant under ecosystem of existence. To measure in quantity feature the final stage of each milestone of agreement is crucially needed to
meter it digitally and create a mechanism of ensuring its stability, reliability and security of data. Nevertheless, an initial digital recording and further transmission the numerals to the blockchain system is still a hard discussed challenge that lies beyond this technology.

However, according to the greatest words of famous author there are three milestones of each good idea: 1. complete mockery; 2. violent denial and 3. acceptance as a necessity (Arthur Schopenhauer).

The abolishment of the heavy envies and taxes as well as unnecessary mediate part in a final price cannot be occurred without weight reasons for that, just because the beneficiaries of the system are not interested in changings. The blockchain technology potentially might be that specific reason for transformation energy sector towards prosperity of entire economy so as the energy sector is a primary factor for other industries. However, in these assumptions there are lots of factors that could not be counted and also some features are still unavailable for a complete evidence of potential benefits. For example:

- The blockchain technology consumes resources which are not usually taken into account but it does. The size of these consumptions depends on too many reasons which are not acceptable to discuss.
- Second, it is assumed that price for the electricity is equal in both cases, but practically it is unlikely to be happened, when as widely known, the price from “green kWh” is usually higher.
- Third, the government policy in taxation in particular and policy of economic support can be adapted to any current system as well, and this movement usually cannot be predicted in advance.

Nevertheless, this paper is making an attempt to describe the assumed situation and significant potential benefits when domestic electricity market will slowly move towards mass blockchain invention which irreversibly lead out to such or closely positive effect.

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