Creating an Energy-Efficient University Blockchain

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Abstract: A much-discussed issue of blockchain technology in the scientific world is that blockchains consume large amounts of electrical energy for their sustainability and operation, which has a harmful effect on the environment. During my research, I am looking for the answer to what blockchain technologies are available that would consume less electrical energy, and whether a blockchain with a higher electrical energy demand can be sustained using renewable energy sources in today's world. As part of the practical implementation, I am creating a private university blockchain to store data. After that, it was calculated how much electrical energy is needed to operate this blockchain. I will investigate what kind of solar solution I can use to reduce the operating costs of the blockchain I'm creating while keeping in mind that this blockchain uses a renewable energy source. My research goal is to propose ways to make blockchains "greener".

Keywords: Blockchain Technology, Solar panel, Green energy

1 Introduction

As a result of continuous development and digitization, more and more devices that consume electrical energy appear daily. The high economic growth rate of developing countries increases energy consumption, and because of this, the electrical energy demand will increase by 28% by 2040. It is irresponsible to meet this level of electrical energy demand with fossil energy, therefore renewable energies must be prioritized and used. Solar energy is in constant transformation, analogue solar solutions have been replaced by digital systems [1].

With the advent of blockchain technology, there is an even greater demand for rooftop photovoltaic (PV) systems [2] since the mining difficulty is constantly increasing, because of which the energy consumption required to produce the blocks is also continuously increasing. During the production of the blocks, the goal is to use the most efficient renewable energy. The blockchain is a decentralized system that works on a mathematical basis, so the trust that the blockchain provides can be established more easily than in the case of a centralized solution. It can be used effectively in many areas of life, such as in the energy sector, as it provides transparency, reliability and, if necessary, anonymity for the parties. Carbon dioxide emissions are also beneficial for the trading system, as it makes the energy sector distributed and thus require solving many problems, such as distributed storage, control, management, and trading. Traditional energy systems cannot solve these problems, while the features of the blockchain can provide solutions [3]. In addition, blockchain is used with great efficiency in many other areas of life, which is presented in the first figure.

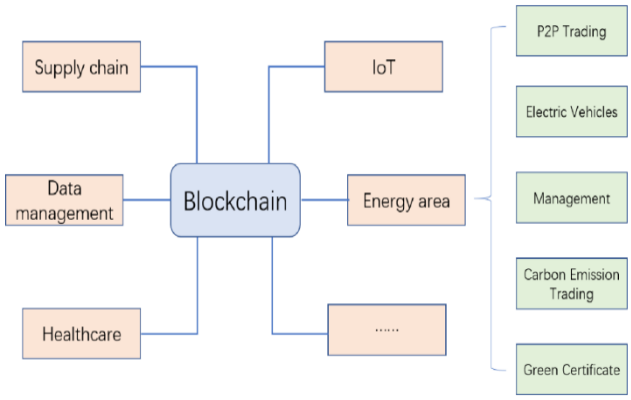

Figure 1.
Possibilities of applying blockchain technology in everyday life [3]

The use of solar energy is essential, but paying for it is already a complex task, which requires a bilateral agreement by the parties, as well as the conclusion of a contract. The days are longer in the summer and shorter in the winter, which affects the efficiency of rooftop photovoltaics (PV), and the prices may change accordingly. It would be advisable to formulate a condition advantageous for both parties and to use a smart contract to comply with it. Companies that sell solar energy pay their customers not immediately, but with a delay of 1-2 months, which can even have a negative impact on the business [4]. Also, by means of a blockchain-based smart contract, daily energy price changes could be recorded automatically, which would enable more accurate payments. It is advisable to choose from the following smart contract platforms to record this type of contract:

- In Ethereum, the 160-bit addresses of user accounts are derived from public keys, and in the case of contract accounts, they consist of the address of the creator of the contract and the nonce address, [5] which results in a very efficient and secure smart contract platform.

- The Solana network runs the mathematical functions in real-time, which also offers reliable smart contracts for application. A big advantage is that you don't have to waste computing resources to synchronize the time, since the time is preset for you and cannot be changed. If we want to know the hash value when the index is 300, the only way to do this is to run this algorithm 300 times. Based on this, we can conclude from the specific data structure that the smart contract process takes place in real-time [6].

The research is structured according to the following structure:

- Proof-of-Work and Proof-of-Stake consensus examination, considering power consumption requirements,
- Creating a blockchain called Óbuda University suitable for university data storage,
- Calculation of the solar electrical energy demand of a Óbuda University blockchain suitable for university data storage.

2 Proof-of-Work and Proof-of-Stake Consensus Mechanisms

As stated in the previous chapter, blockchain technology has a very important place in the use of renewable energy, as well as in its administration, even if the operation of the blockchain itself requires a lot of energy. Blockchains use several types of consensus mechanisms. The following two mechanisms are the most common in the crypto world:

- Proof-of-Work (POW),
- Proof-of-Stake (POS).

The Bitcoin blockchain network uses Proof-of-work consensus. This is one of the earliest and most widespread solutions for nodes to verify transactions. This requires a serious calculation [7]. During PoW, the algorithm distributes rewards to the miners who produce the blocks. The essence of this algorithm is that only those who have sufficient computing capacity can create new blocks. Although the PoW algorithm is used by the largest cryptocurrencies, this method has certain disadvantages. Solving computational tasks requires a lot of time and energy, so it is a relatively expensive process [8]. The second figure shows the Bitcoin difficulty historical chart. This leads to the conclusion that the mining computing capacity increases continuously in direct proportion to the power requirement, because the more difficult a mathematical operation is, the more power it requires.

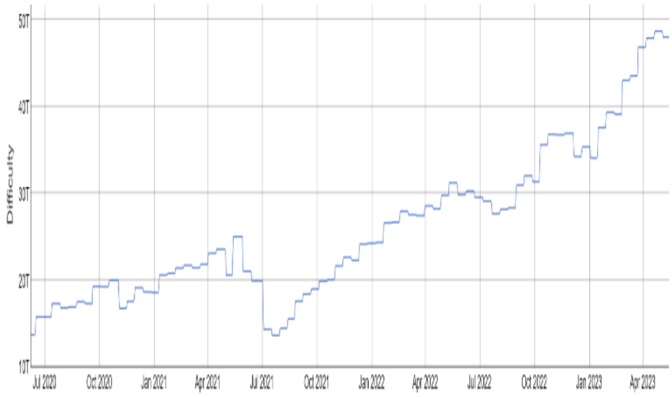

Figure 2
Bitcoin difficulty historical chart [9]

Since the electrical energy demand for the calculation of blocks increases drastically, miners use renewable energy sources to reduce their production costs. The Bitcoin Mining Council (BMC), which represents the global forum of mining companies, stated that in the year 2022, 59% of the mining industry used renewable energy sources. In the previous year 2021, only 37% of renewable energy sources were used. In their view, their goal in the coming years is to make mining even greener [10].

The Proof-of-Stake algorithm uses a so-called "random" selection process to select validators from a pool of nodes. The system uses a combination of several factors simultaneously, including staking time, an element of randomness, and node wealth. In Proof-of-Stake systems, blocks are produced, not mine. However, the term mining is often used. Most Proof of Stake cryptocurrencies starts with a pre-minted coin offering so that nodes can start immediately. In the random block selection method, validators are selected by looking for nodes with the lowest hash value and the highest stake combination [11].

The Ethereum blockchain initially used a POW consensus but switched to the POS mechanism in 2022 during an update called Merge. In the third figure, you can clearly see that the mining difficulty did not decrease, instead disappeared, since Ethereum could no longer be mined. This method has made the blockchain green as its power consumption has been drastically reduced. This is shown in the third figure.

Figure 3
Ethereum difficulty historical chart [12]

Based on these, it can be concluded that blockchains using POS consensus use much less electrical energy than those using POW solutions. It is unnecessary to assume that Bitcoin will switch to POS consensus since BTC was the very first crypto blockchain, so its operation will not be changed at this level, because then the original Bitcoin blockchain itself would be "damaged", thereby losing its original state. Currently, the POW consensus uses the most electrical energy to mine blocks. This is presented in the first table below. This is shown in the first table.

Blockchain	Consensus protocol	Hash function	Energy consumption
Bitcoin (BTC)	POW	SHA-256	Annual energy consumption 160 TWh
Ethereum (ETH)	POW (to 2022) POS (from 2022)	Ethash	The annual consumption 74.6 TWh. 99.95% less energy after the Merge

Table 1.
Energy consumption of cryptocurrencies [13]

3 Creation of a Blockchain Called ÓUB (Óbuda University Blockchain)

The system of prioritized skills is constantly changing, so higher education institutions must adapt to new solutions [14]. The blockchain technology used for university data storage is a novelty that few universities use in everyday life.

The ÓUB blockchain is a blockchain suitable for data storage. Due to its structure, it can store university data in blocks, which are closely connected to each other, thus creating the blockchain. It uses a Proof-of-Stake solution instead of Proof-of-Work, thus ensuring less power consumption and a high degree of security. This blockchain can also store sensitive university data more securely than a centralized data store.

The power supply of the blockchain must be continuous, however, the productivity of the PV system varies. In accordance with Hungarian rules, a balance settlement must be applied. This means that the excess energy produced is sold by the system, and when the solar production is not sufficient, electrical energy must be purchased. The essence of the operation of the solar system is that at the end of the balance settlement, the expenditure should not be more than the income.

Creating a blockchain does not involve high costs. To develop and operate it, only one IT specialist is needed, who take care of the various blockchain maintenance processes.

The creation of a university private blockchain provides the opportunity to safely save the university's sensitive data in the blockchain instead of centralized data storage. When a blockchain is created, its operating conditions must be defined. These are the following:

- Choosing the optimal block size. Because if the block is too big, the blockchain will run slower. In the case of consumer trends and purchases, defining a block size of 1 MB is more than enough, since in this case, consumer and customer data are recorded.
- The rules for joining the blockchain must be clearly defined so that they are easy to understand for customers.
- The security rules and regulations for the operation of the blockchain must be recorded.
- Access to the server must be strictly limited so that no unauthorized person can access it [15].

The fourth figure shows the steps for creating the genesis block of the Óbuda University Blockchain (ÓUB). After the genesis block is created, the other blocks will be generated.

```
{
"config": { // the config block defines the settings for our custom chain and has certain attributes to
create a private blockchain
"chainId": 987, // identifies ÓUB blockchain.
}
"homesteadBlock": 0, // Homestead version was released with a few backward-incompatible protocol
changes, and therefore requires a hard fork. UDSC chain however won't be hard-forking for these
changes, so leave as 0
"eip155Block": 0, // Homestead version was released with a few backward-incompatible protocol
changes, and therefore requires a hard fork. UDSC chain however won't be hard-forking for these
changes, so leave as 0
"eip158Block": 0
},
"difficulty": "0x400", // This value is used to control the Block generation time of a Blockchain. The
higher the difficulty, the statistically more calculations a Miner must perform to discover a valid block.
"gasLimit": "0x8000000",
"alloc": {}}
}
```

Figure 4.
Creating a genesis block [15]

The blockchain must be created in such a way that it can store sender and receiver data and record order data. The structure of the creation of the blockchain is presented in the fifth figure.

Óbuda University Blockchain-util generate ÓUB
the default settings would be used:
/default ~ university chain/ ÓUB /chainsettings.dat
chainsettings.dat include:
Database addresses [receiver (cloud storage) IP address, sender (university) IP address],
Database system addresses [receiver (university database) IP address, sender IP address],
Terms of GDPR database.
Next, the *ÓUB* blockchain would be initialized, and the genesis block would be created
university blockchain ÓUB
The server will be started in those few seconds after the genesis block has been found, then the node address needs to be connected:
ÓUB@192.168.0.1:8008
After these steps, the connection can be attempted from a second server:
university blockchain ÓUB@192.168.0.1:8008
After the message confirming the chain has been initialized, permission is not given for connection to the database.
The address would be copied and pasted: 192.168.0.2
finally, permission for connection would be granted:
university blockchain ÓUB grant 192.168.0.2 connect.

Figure 5.
The creation of an ÓUB blockchain [15; 16; 17]

After the creation of the blockchain, I examined the electrical energy required for its operation, which I will present in the next chapter.

4 Calculation of the Solar Electrical Energy Demand of a Óbuda University Blockchain Suitable for University Data Storage

Clean and smart technologies such as blockchain computing perfectly aligns with the principles of green to run the processes smoothly without taking up much electricity [18]. An average desktop computer, equipped with speakers and a printer, consumes around 200 W of electrical energy. Assuming 8 hours of operation per day, this means an annual consumption of nearly 600 kWh, which results in 175 kg of CO2 emissions. In the case of a laptop, power consumption of 50-100 watts/hour should be expected. Calculating with 8 hours of daily use on an annual basis, we get a much lower value, approximately 150-300 kWh, which results in 44-88 kg CO2 emissions per year. In terms of economy, the laptop is certainly the better choice [19].

To run a decentralized private blockchain suitable for university data storage, you need at least 2 server-level computer capacities, which start working when the blockchain is created. These computers have a higher capacity than traditional desktop computers, so their power consumption is also higher, they use approximately 1000 W of power in total. Since blockchain is run on them, they need to work all day. This means an annual consumption of 9,000 kWh.

Nowadays, the monocrystalline 460Wp solar panel, which consists of 156 cells, is the most common. Its parameters and performance are illustrated in the second table.

Solar panel module properties		
Module efficiency	20.6	
Tolerance (W)	0	~ +5
Test environment	STC: irradiation power 1000 W/m2, cell temperature 25°C, AM1.5	NOCT: irradiance 800W/m2, ambient temperature 20°C, wind speed 1m/s
Maximum power Pmax (W)	460	348
Opening circuit voltage Uoc (V)	50.01	47.38
Short-circuit current Isc (A)	11.45	9.33
Maximum power voltage Um (V)	42.13	39.68
Maximum power current Im (A)	10.92	8.76
Operating temperature range (°C)	-40	+85
Size (mm)	2120×1052x40	
Weight (kg)	25	

Table 2.
Specificity of JA Solar JAM72S20-460/MR Monocrystalline Solar Panel [20]

Based on the second table above, considering the performance of the solar panel module and the capacity of the two blockchain servers, it was calculated the required solar panel investment. Based on this, I received the following results, which apply to a flat university roof structure:

- The size of the system must be 7.44 kWp,
- A quantity of 19 panels is required,
- It is necessary to install a 6 kW inverter, as well as
- A flat roof area of 38 m2 is required.

If the university has a sloping roof, the surface size of the required roof area will also change. In Hungary, considering the geographical location of Budapest, the obtained data are as follows compared to the previous calculation, which is presented in the third table.

Pitched roof	System size	Solar panel number	Inverter	Required roof area
East	9.56 kWp	24	8 kW	48 m2
Southeast	7.92 kWp	20	8 kW	40 m2
South	7.45 kWp	19	6 kW	38 m2
Southwest	8.01 kWp	20	8 kW	40 m2
West	9.72 kWp	24	8 kW	48 m2

Table 3.
Required Solar Panel Installation Calculation for Pitched Roofs

Conclusions

The development of blockchain technology is unstoppable. Daily, more and more blockchains are appearing, which provide solutions to many IT problems.

However, blockchains require electrical energy to operate. For the sake of long-term sustainability, it is advisable to use a renewable energy source. The solar energy source is now within reach, as their price has decreased significantly in recent years and their efficiency has increased.

By installing solar panels, the cost of blockchain operation can be kept low, which is a beneficial feature for the future.

In addition to using renewable energy sources, I recommend getting modern computers that consume less electrical energy, so less electrical energy will be needed to operate blockchains.

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