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Comparative Analysis of Energy Consumption of Cryptocurrencies with Experimental Study Approach in the Scope of Green Computing

Kripto Paraların Enerji Tüketiminin Yeşil Bilişim Kapsamında Deneysel Çalışma Yaklaşımıyla Karşılaştırmalı Analizi

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Öz

Günümüz teknolojileri arasında, kripto paranın popüler teknoloji olduğu söylenebilir. Bir para birimi ve kriptoloji karışımı olan bu teknoloji, tüm dünyada artan bir ivme ile kullanılmaktadır. Dolayısıyla kripto para teknolojisi hala bankasız ödeme yapmak için kullanılmakta ve sanal para birimi olarak kabul edilmektedir. Kripto para biriminin sağladığı fırsatların yanı sıra, birkaç zorluğunun da olduğu belirtilmelidir. Çevre için en tehlikeli ve kritik durum, kripto para madenciliği için gerekli olan enerji tüketimidir. Bu kritik duruma göre, popüler kripto para birimlerinden biri olan Ethereum, enerji tüketimini analiz etmek için deneysel bir çalışmada kullanılmıştır. Bu deneyde, 30 Mart 2017 ile 30 Aralık 2019 tarihleri arasındaki verileri incelenmiştir. Elde edilen veriler, çevre için daha iyi olanı bulmak amacıyla bir başka popüler kripto para birimi olan bitcoin ile karşılaştırılmıştır. Bu çalışmada 196 GPU'dan gelen veriler incelenerek elektrik tüketimi ve kazancı analiz edilmiştir. Toplamda 3 farklı GPU markası kullanılmış ve sırasıyla ünitelerin markası, tüketilen güç ve testin yapıldığı ülkedeki elektrik birim fiyatı analiz edilmiştir. Literatürde yapılan çalışmalara göre kripto para üretiminde ciddi enerji tüketimi olmaktadır. Yapılan bu çalışmada, ethereum üretiminde de çok fazla enerji tüketimi olduğu tespit edilmiştir.

Anahtar Kelimeler: Kriptopara, Yeşil bilişim, enerji tüketimi, Ethereum, blok zinciri, kripto madenciliği, teknoloji ve yenilik yönetimi

Makale Türü: Araştırma

Abstract

In today's environment, cryptocurrency is the most popular technology. This technology, which is a relative mixture of currency and cryptology, is used all over the world with increasing acceleration. So, cryptocurrency technology is still used to make payments without banks and is considered virtual currency. Besides this opportunity, cryptocurrency has a few challenges. The most dangerous and critical challenge for the environment is energy consumption in the mining of cryptocurrency. According to this critical challenge, Ethereum which is one of the popular cryptocurrencies, was used in an experimental study to analyze energy consumption. The experiment examined the data from Mar 30, 2017, to Dec 30, 2019. These data were compared with another popular cryptocurrency which is bitcoin to find the better one for the environment. In this study, the data from 196 GPUs were examined and electricity consumption and gain were analyzed. 3 different types of GPU brands were used, and the brand of the units, the power consumed, and the electricity unit price in the country where it was tested were analyzed respectively. According to the studies in the literature, there is serious energy consumption in the production of cryptocurrency. In this study, it was determined that there is a lot of energy consumption in the production of Ethereum.

Keywords: Cryptocurrency, green computing, energy consumption, Ethereum, blockchain, crypto mining, technology, and innovation management

Paper Type: Research

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Introduction

Cryptocurrency is a hot and new technology in our life and global market. However, crypto payment is not a new concept in the technology world since, technology met crypto payment in 1983 (Chaum, 1983, s. 201). But the official introduction of the first cryptocurrency was in 2008 which is bitcoin by Nakatomo (Nakamoto, 2008, s. 21). Cryptocurrency has gained popularity, especially in the last 5 years, and attracted much attention from humanity. Nowadays, the popularity of cryptocurrencies is growing rapidly making it electronic money or virtual currency.

The basic idea under cryptocurrency is that no organization or third party significantly affects the production of cryptocurrency. The production rate is set by a value defined in advance and is known publicly. So, cryptocurrency allows virtually costless transfers between client transactions through peer-to-peer (P2P), distributed networks (Greenberg, 2011, s. 40).

In a P2P network, all clients have equal peers that are called miners. So, the process of making cryptocurrency is mining. All transactions done by cryptocurrencies are stored in a distributed ledger, which is called blockchain (Sharma, 2020, s. 37).

1. Blockchain

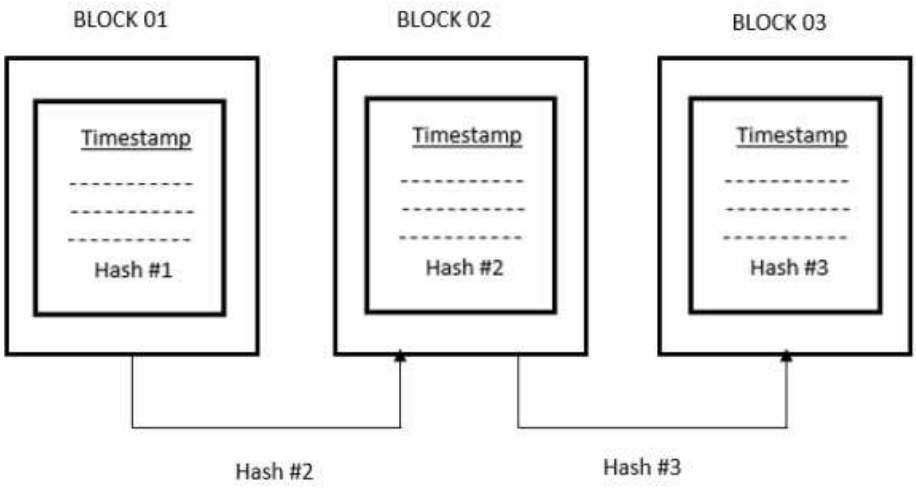
Blockchain technology is almost the newest technology. Blockchain has become much more popular with cryptocurrency but it is used in various areas such as healthcare, advertising, insurance, finance, and voting (Wang et. al, 2018, s. 24; Foroglou & Tsilidou, 2015, s. 4). In the concept of cryptocurrency, the first blockchain was introduced in 2008 called bitcoin (Awasthi, 2015, s. 113). As mentioned above, many other cryptocurrencies were introduced and used in the financial sector after Bitcoin.

Blockchain is a digital ledger that stores agreements between parties on the current ownership and distribution of assets (Teufel et. al, 2019, s. 221). In other words, blockchain is some kind of data structure that uses a P2P network to save information in a computer file. It means that every node(pc) has a copy of the file that will intend to use blockchain (Bai et. al., 2021, s. 321). According to IBM, blockchain is "a sequence of blocks or groups of transactions that are chained together and distributed among the users" (Laurence, 2019, s. 187). Blocks in blockchain, are made up of digital pieces of information and they record (Burgwinkel, 2016, s. 144);

- Transaction information about the date, time, or money spent.
- Participant information who are in trans-action.
- Information that distinguishes them from other blocks.
- The working process of blockchain technology is as follows (Buterin, 2015, s. 175);
- Blockchain technology implements a P2P network and each node can download one more multiple chain. In other words, a transaction must occur.
- After making the purchase, the transaction must be verified.
- After your transaction has been verified, transaction information must be stored in a block.
- When all of the block's transactions are verified, it must be given a unique, identifying code called a cryptographic hash. Once hashed, the block can be added to the blockchain.

Block reaches a certain size after the transaction was verified, done, and recorded individually. Block timestamped and connected to the other block through the hash. Figure 1 illustrates the scenario, in which every block timestamp and connected with hash cryptography. So, Hashes are cryptographic codes created by special algorithms that transform any input data into a fixed-length string of numbers (Catalini, 2017, s. 91).

Figure 1: Simple Blockchain Architecture



Source: Shrimali & Patel, 2022, s. 6799

Miners who are producing cryptocurrencies, collect and verify whether the data contained in them is correct. When the verification processes finish, miners must use their PC resources to solve cryptographic algorithms to produce cryptocurrency.

1.1. Ethereum and Mining Process

In the technology world, there are too many cryptocurrencies, but the most popular cryptocurrencies are Bitcoin, and Ethereum as shown in Table 1.

Table 1. Popular cryptocurrencies

Rank	Name	Symbol	Market Cap	Price	Circulating Supply	volume (24h)	% 1h	% 24h	% 7d
1	Bitcoin	BTC	$320,025,834,692.40	$16,625.08	19,249,581 BTC	$9,244,381,899.89	0.07%	0.47%	-1.29%
2	Ethereum	ETH	$146,966,709,631.13	$1,200.96	122,373,866 ETH *	$2,388,674,550.06	-0.04%	0.35%	-1.48%
3	Tether	USDT	$66,243,284,943.48	$0.9997	66,263,713,431 USDT *	$11,344,984,017.59	<0.01%	<0.01%	-0.03%
4	USD Coin	USDC	$44,584,840,756.22	$0.9999	44,585,140,660 USDC *	$1,197,027,575.87	-0.01%	0.00%	-0.01%
5	BNB	BNB	$39,053,283,491.06	$244.14	159,964,553 BNB *	$278,651,738.80	-0.31%	-0.90%	0.41%
6	XRP	XRP	$17,054,534,692.06	$0.3388	50,343,500,506 XRP *	$290,828,851.37	0.07%	-0.34%	-2.20%
7	Binance USD	BUSD	$16,566,063,279.88	$1.0003	16,560,434,934 BUSD *	$2,236,386,722.01	-0.01%	0.01%	<0.01%
8	Dogecoin	DOGE	$9,316,760,628.85	$0.07022	132,670,764,300 DOGE	$185,279,748.90	0.05%	-0.10%	-7.54%
9	Cardano	ADA	$8,621,727,158.32	$0.2498	34,518,582,841 ADA *	$113,388,988.73	0.26%	1.34%	-3.66%
10	Polygon	MATIC	$8,637,843,574.08	$0.76	8,734,317,475 MATIC *	$106,486,710.51	0.27%	0.19%	-4.43%

Source: CoinMarketCap, 2023, s. 1

Ethereum was created by Vitalik Buterin as a decentralized application platform and next-generation smart contract for cryptocurrency use (Buterin, 2014, s. 41). According to Buterin, Ethereum is an innovative system aimed at the development of blockchain technology to be used in more areas. According to Buterin, Ethereum is an open-source platform based on Blockchain technology that enables developers to create and deploy decentralized applications. Shortly, Ethereum is a Crypto Operating System that takes Ether (ETH) cryptocurrency as its power source.

The purpose of Ethereum is to prevent information such as personal data from being stored by third parties and used for different purposes and enable users to create new software on the blockchain system. Hence, transactions are completely decentralized and anonymously stored

on many different devices. To create the software(s) that will be included in this decentralized Ethereum system, each user must use the mining procedure for Ether cryptocurrency as a fuel in one aspect (Bogner et .al. 2016, s.178).

The mining procedure is just one of many differences between Ethereum and other cryptocurrencies, but it is the most important (Gencer et. al. 2018, s. 451).

Cryptocurrency mining is performed to check the validity of money being transferred, and accurately record the transaction information and transfer time of the receiver and the sender. If the money sent during this process is proven to be correct, it is processed into blocks and the process continues continuously (Castellanos et. al. 2018, s. 369). Today, graphic transaction units with strong transaction volumes are used to solve the algorithm of virtual currency. The reason for this is that the difficulty level of a created block is due to the increase in the number of floors.

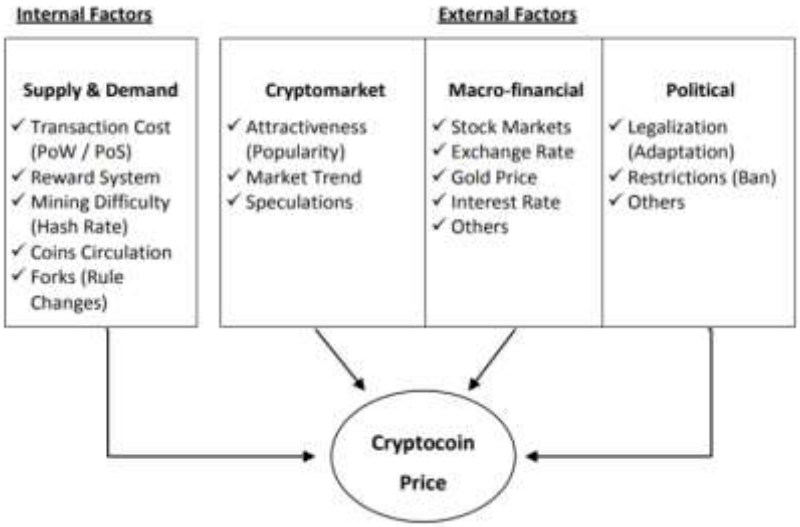
Before cryptocurrencies started to become popular, virtual money mining could be made easier with less energy spent due to low difficulty levels. While it is possible to process the Ethereum virtual currency with CPU, nowadays all miners prefer to use the Graphics processing unit with the increasing difficulty level. The graphics processing units integrate multiple Graphics processing units into a single motherboard, allowing them to work synchronically and solve more hashes in this way, as central processing units can perform operations faster (Noda et. al. 2019, s. 55).

The created transactions are accumulated in the mining pool where they are registered at the request of the miners. These mining pools share the accumulated transactions according to the number of graphic processing units of the miners to other mandates connected to the pool. After the completion of the shared transactions, the miner who completes the transaction is paid as a reward from the virtual currency in which the transaction is made. The miner can sell this profit from virtual money exchanges and convert it into real money. In this case, the amount earned may vary depending on the value of the virtual currency on the stock exchange, the performance of the graphics trading units, the trading volume of the mining pool, the commission percentage of the mining pool, and the profit distribution model (Zamyatin et. al. 2017, s. 102). The mining pool should not reach 51% of the entire network and where it reaches 51%, it is thought that it could theoretically crash the entire network, and this situation is called a 51% attack or double-spending attack (Bae & Lim, 2018, s. 81).

Ethereum mining uses motherboards on which you can install more than one graphics processing unit, as well as an external card unit that allows you to easily connect graphics processing units to the motherboard. The central processing unit does not need to be too strong; an ordinary dual-core processor, which would be at least 4 GB of the temporary memory unit, a power supply suitable for the graphics processing units used, an internet interface and a hard disk are sufficient for mining. After the whole system is integrated into the motherboards as a whole, the cooling mechanism of the system should be done correctly to optimize the performance of the graphics memory units. The temperature increases in the graphic processing units due to the hot air may affect the system's operation. This temperature differs between graphic processing units and maintains its efficiency up to a maximum of 110 degrees. After determining your operating system, the address of the registered pool and the virtual wallet of the miner are registered in the pool system. The profit earned as a result of each transaction is sent to the miner’s virtual wallet during the periodic times when the pool is beveled.

Earnings received in mining, the value of the pool together with its distribution system may vary, including internal and external factors. The factors that directly affect the value of the virtual currency may be the changes in the rules of the virtual currency, degree of difficulty, supply and demand for virtual money, the trading volume of the exchange where the purchase and sale are made, can be listed as the earning policy (Sovbetov, 2018, s. 19).

Figure 2: Factors affecting virtual money



Source: Sovbetov, 2018, s. 19

1.2. Energy Consumption

Considering this expenditure and a miner's need for more powerful interfaces than a normal computer, the average power supply required in a ring system of approximately 10 is 750-1300 watts. In today's technology, the electrical energy consumed by GPUs used in the sectors that do business with players and graphics operations is between 200-270 watts, and this rate causes serious electricity consumption (Mills & Mills, 2016, s. 334). Most of the graphics cards developed for miners aim to provide high efficiency with low energy, but each of these graphics cards consumes 100-200-Watt energy. The hourly Watt energy spent according to the miner's number of cards is between 1200-1450 Watt per ring of 10. The total energy used by the 196 GPUs in this study was observed as 692.928 watts/hour daily (Krause & Tolaymat, 2018, s. 715).

According to the researchers, the average mining efficiency was 500W per GH/s between 2010 to 2013 (Garcia et. al., 2014, s. 348). However, Hayes calculate the approximate cost of electricity, which was close to the market value of bitcoin in 2017 (Hayes, 2017, s. 1317). In 2018, Digiconomist estimated the annual electricity consumption of Bitcoin is 63.99 TWh, but the annual electricity consumption of Ethereum is 18.09 TWh (Jeyanthi, 2020, s. 231).

The mining process of any cryptocurrency contains many costs, equipment, facilities, labor, and electricity. Based on the electricity consumption some countries used their geographical advantage and become a cryptocurrency state or country. These are (Chitchyan & Murkin, 2018, s. 401; Albrecht et. al. 2018, s. 293);

- New York: New York developed various kinds of policies in response to the growth in energy demand by cryptocurrency mining activities.
- Washington: Washington uses hydroelectric facilities to keep the costs of electricity relatively low.
- Canada: Canada established hydroelectric power stations like Washington, but Canada has another advantage over Washington as it has a cold weather climate, which can reduce overall cooling costs and effort.
- Georgia: Georgia has large hydropower resources for producing energy, so Georgia has a low electricity price.

- Iran is another country which is the electricity price is low like Georgia. Except for Georgia and other countries, Iran produces their natural gases and uses gas for electricity. Because of this, electricity is cheap in Iran.

Nevertheless, many companies use cryptocurrency mining tools for production all around the world. But still, there is a big problem with energy consumption in producing cryptocurrency.

2. Literature Review

In addition to being a very up-to-date topic in technology, cryptocurrency has created new business opportunities. According to this opportunity, many investors set up cryptocurrency farms for various kinds of cryptocurrencies. Today, the number of these production farms has grown rapidly, and production has increased continuously (Singuluri et. al., 2021, s. 77; Patel & Burla, 2020, s. 166). Apart from this opportunity, each cryptocurrency has different problems except energy consumption.

Energy consumption is the most dangerous problem for all cryptocurrencies since some production farms produce cryptocurrency but consume more energy even more than houses during the production phase. When the consumption is excessive, it does not have any profit for the investor yet it harms the environment. In the literature, researchers applied some green technology methods to find out the consumption rate and try to solve the consumption problem (Imbault et .al. 2017, s. 4; Li et. al. 2019, s. 167)

In the literature, many researchers try to analyze energy consumption with simulation or experimental studies. Many researchers used various types of hardware and high-efficiency ASIC machine in their experimental study with different scenarios. Researchers calculated total energy consumption depending on the hardware which was used in the mining process. According to analysis, it is still quite hard to know exactly which version of hardware is compatible for mining process and cryptocurrency type (Vranken, 2017, s. 8; O'Dwyer & Malone, 2014, s. 77; Gauer, 2017, s. 4; De Vries, 2018, s. 803; Bevand, 2017, s. 2; Küfeoğlu & Özkuran, 2019, s. 101273).

Other researchers aimed to calculate and minimize energy consumption. This research aims to assess the performance of combined power and heat plants in trigeneration mode. This mode will enhance the total energy performance of mining farms (Rusovs et. al. 2018, s. 3).

On the other hand, researchers examined the relationship between the energy consumption of Bitcoin and miners' revenue. With the results of empirical analysis, researchers concluded that there is not any positive impact between them. When the revenues are volatile and low, this negative impact is seriously important (Das & Dutta, 2020, s. 108530).

Another research was done by researchers about cryptocurrency consumption. Researchers (Huynh et. al. 2022, s. 81) used daily data over the period 2017 – 2019 to analyze Bitcoin energy consumption in its market based on two criteria (yield and volume). We show a bidirectional effect between energy consumption and Bitcoin returns (and volumes). In particular, it is likely to be linked to higher energy consumption following the Bitcoin crash. The research was also in line with the previous literature of Truby that Bitcoin mining and processing appears to be an inefficient use of scarce energy resources, even though Bitcoin has many financial advantages (Truby, 2018, s. 402). Indeed, many researchers warned that Bitcoin could be considered a power-hungry cryptocurrency (Mora et al. 2018, s. 932; Howson, 2019, s. 645). According to this research, Therefore, we suggested that the Fintech industries (or the projects) should consider issuing cryptocurrencies-backed-to green energy by issuing the 'green token' to finance sustainable development (Kovilage, 2021, s. 137).

Another study deals with the environmental aspects of crypto-currencies trading through its statistical relationship with energy consumption. The study examines the effects of cryptocurrency trading on energy consumption over the period 2014M1-2017M12. The data for

the Bitcoin and 1636 cryptocurrencies trading volume combined with primary energy consumption were collected for analysis of time series through the application of econometric techniques. The findings of the study show a negative influence of the trading of crypto-currencies - precisely, the higher the crypto-currency activities are, the higher the energy consumption is, affecting, therefore, the environment (Schinckus, 2020, s. 305).

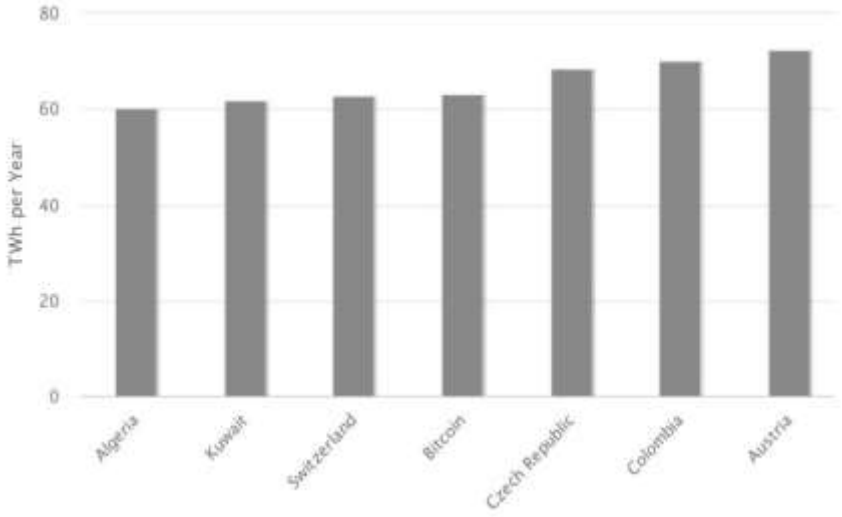
Lastly, another study was done by researchers related to cryptocurrencies and energy consumption. Researchers compare the energy consumption and carbon footprints of these cryptocurrencies with countries around the world and centralized transaction methods such as Visa. Researchers identify the problems associated with cryptocurrencies and propose solutions that can help reduce their energy consumption and carbon footprints. Finally, we present case studies on cryptocurrency networks, namely, Ethereum 2.0 and Pi Network, with a discussion on how can solve some of the challenges (Kohli et. al., 2023, s. 80).

Apart from these researches, few researchers performed analyses to prevent energy consumption during the mining process. The authors proposed an innovative scheme that minimizes the nonce and thus the burden of the PoW (Proof of Work). According to research, authors analyzed and showed that the proposed technique decreases consumption (Jacquet & Mans, 2019, s. 211).

2. Methodology

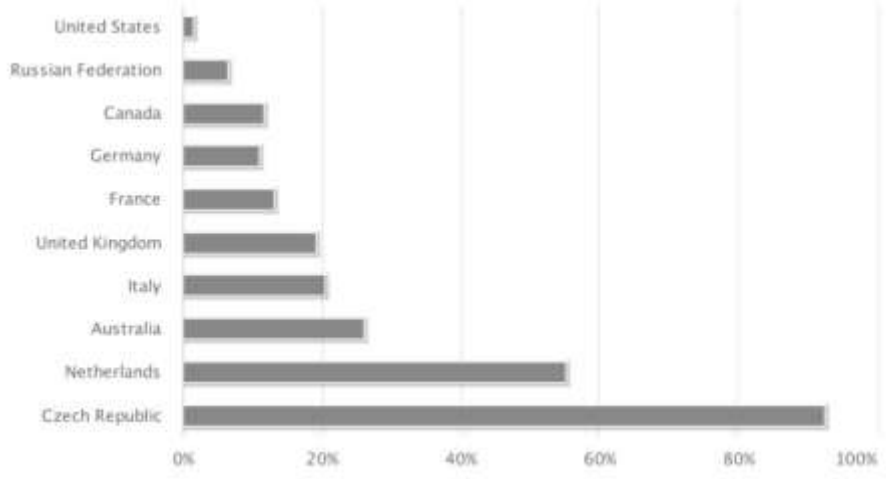
As mentioned above in Table 1, bitcoin is the first rank in the cryptocurrency list. But bitcoin has many problems and energy consumption is one of the biggest. In the 3rd quarter of 2018, Canadian bitcoin miners reported that 1.16 million US dollar net loss (Symitsi & Chalvatzis, 2018, s. 128; Das & Dutta, 2020, s. 108530). Another report explained that Bitcoin was estimated to consume at least 2.55 GW of electricity in 2018. Potentially, it will be more than 7.67 end of 2020. When compared with countries, Ireland has 3.1 GW, and Austria's 8.2 GW of energy consumption (De Vries, 2018, s. 803). According to these records, the energy consumption of Bitcoin will be more than many countries' demand. Additionally, Digiconomist (Index, 2017, s. 8) compared Bitcoin and countries' energy consumption. The results of the comparison are shown in figure 3 explaining that bitcoin energy consumption is more than many countries. Figure 4 explains Bitcoin energy consumption according to several countries.

Figure 3: Energy consumption by Country chart



Source: Index, 2017, s. 8

Figure 4: Factors affecting virtual money



Source: Index, 2017, s. 8

Apart from this, Before Bitcoin becomes the main currency on which other currencies are based, it is aimed to halve the earnings given for the reward every four years and to create a new block every 10 minutes. The amount envisaged in this targeting was determined as 21 million by the Bitcoin creator, and with this limitation, it was thought that Bitcoin would approach the same value compared to normal currencies (Durmuş, 2018, s. 668).

Because of these problems, ethereum will be the future solution for the cryptocurrency energy problem. In the literature, there is not any experimental research about Ethereum energy consumption. So, this research aims to prove that Ethereum is the choice for miners of energy consumption.

3.1. Experimental Study

In the system installed for this study, 3 different brands of Graphic Processing Unit Series, namely AMD Radeon RX 580, Asus P106-100 Mining 6GB, Sapphire Radeon RX 580, a total of 196 Graphics Processing Units, Corsair HXi Series, HX1200i, Corsair HXi, AX1500i. 2 different power supplies, 38 power supplies, 196 Boosters, 8 GPU ASUS ROG STRIX Z270E GAMING LGA1151, 13 GPU ASRock Super Alloy H110 Pro, 20 motherboards in total, 20 Intel Pentium Dual Core 4400 Processors, 20 Kingston 8 GB ram, 'simple mining' Online Linux mining operating system, 20 flash memory and 20 aluminum and wooden cases, 38 electricity meters were used.

To use and protect the necessary hardware, the safe was installed at the first stage. Then, the motherboards were placed in the established case in the specified order and intervals and a connection was made between the rise and the motherboards specially made for mining. The 'simple mining' operating system, which was downloaded online after the ram and processor were placed on the motherboard, was inserted into any USB port on the motherboard after being thrown into the flash memory. The wallet and ETH pool settings were made on the website of the 'Simple Mining' operating system and the Ethereum pool in Europe was chosen as the pool because the earnings are given to the European 1 Ethereum Pool System and the fee received by the pool were appropriate. In the next process, the values given by the graphics processing units were checked in case of any problems in the graphics processing units. One of the average graphics processing units of the graphics 10 processing units purchased from the distributor and directly from the factory either did not work at all or was measured less than the expected Mhz. When enquired, we were informed that the normal state was normal and they changed graphic

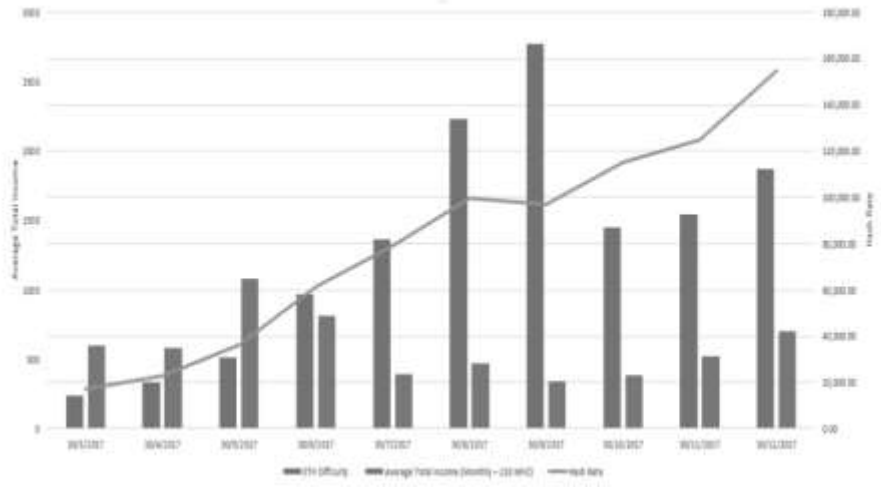
processing units that did not work at all. During the studies, the temperature of the room where the cases were located was kept between 17- 21 degrees, and for this, a cooling fan and a mechanism that draws hot air were installed and the graphics processing units were kept at a low temperature. In the observations made, it has been observed that the graphical processing units that make mining process virtual currency at different values from time to time, and this loss of value is generally caused by the graphics processing units. Hence, there were no problems with other components other than risers, and the problematic risers usually caused issues due to factory defects. More stable Mhz values were examined compared to the other graphics processing units using the Asus P106-100, and it was better than the Sapphire Radeon RX 580 and AMD Radeon RX 580 in terms of heat and electricity consumption. When AMD Radeon RX 580s and Sapphire Radeon RX 580 cards were examined, it was seen that AMD Radeon RX 580s were better than Sapphire Radeon X 580 in terms of temperature, and the Sapphire Radeon RX 580 was better in terms of Mhz values. It has been observed that the AMD Radeon RX 580 graphics processing unit, which is generally sold for gamers, is less stable in terms of Mhz values than graphics processing units specially designed for mining.

Considering that in Ethereum mining in 2017, 2018, and 2019, the graphics processing units process less Eth at the same Mhz according to the increasing difficulty level, the power of the new generation mining graphics cards has increased in direct proportion to the difficulty level of virtual currencies. In the last 3 years, it has been observed by the graphics processing units introduced that year in 3 different years that the mining graphics processing units, which were developed in 2017 compared to the previous years, have solved stronger algorithmic problems and gained more profit despite the difficulty level, although the capacitors in the graphics processing units, it is seen that the capacitor and its components are developed very well.

3.2. Results

In the study, the data obtained by mining Ethereum in 2017, 2018, and 2019 were analyzed by examining parameters such as monthly income, electricity consumed, difficulty level, Hash rate, excavation power (MHz) of graphics cards, and system components. In line with these data, the aim was to calculate the total energy consumed by comparing the energy consumed by mining with the world in general.

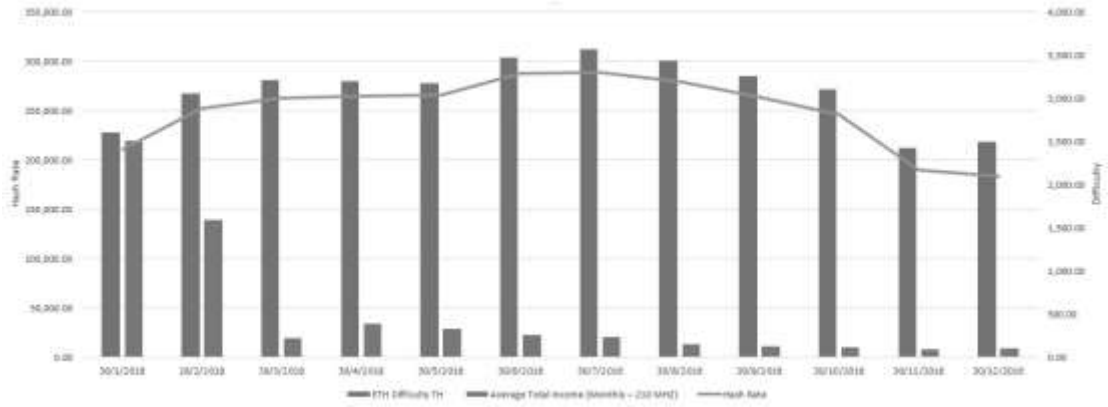
Figure 5: 2017 Hash Rate, Difficulty, and Income Chart



In Figure 5, it is observed that after 10 months of mining with 8 graphics cards in 2017, the maximum value of the Ethereum Hash rate is 157,787.99 and the difficulty level is 2,773.80 at the maximum value. It has been identified that the increase of the Hash rate in the first 4 months of scraping does not have any effect on the earnings, the earnings in May and June have the highest values during the 10-month scraping process, the electricity consumed in 10 months, 150

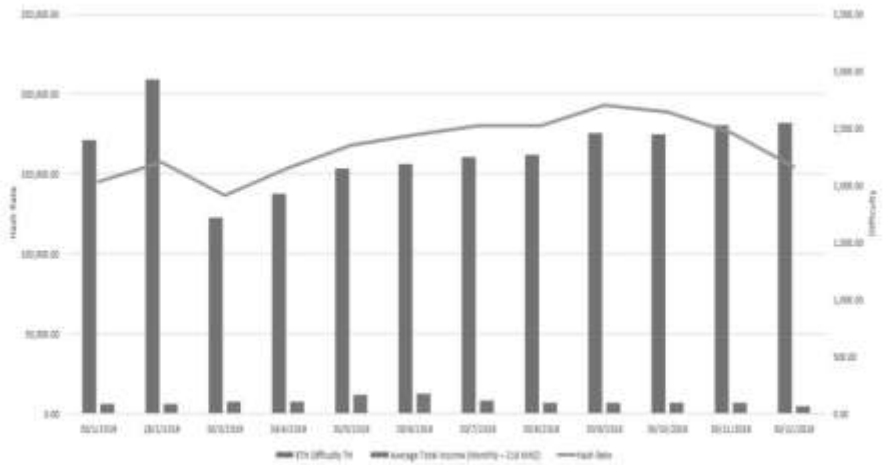
watts per graphics card, 62.4 kW/h per year, 624 kW /h, the annual gain is calculated as 5893.65 US Dollars.

Figure 6: 2018 Hash Rate, Difficulty, and Income Chart



When the 12-month data is examined in Figure 6, it is observed that the Hash rate is a maximum of 289,075.20 and the Ethereum difficulty is 3,562.90 during the 12-month scraping process with 16 graphics cards. Unlike the graphics card used in 2017, a specially produced graphics card was used for mining. According to this graphics card, there was a serious decrease in the previous electricity consumption, 117 watts per video card, 50.4 kW / h per day, and 604.8 kW / h electricity per year, with an annual gain of 6,129 US Dollars. The difficulty level and the high hash rate in January and February did not affect the income, and a significant decrease in income was observed with the increasing difficulty and hash rate in other months.

Figure 7: 2019 Hash Rate, Difficulty, and Income Chart



In Figure 7, with the increasing demand for Ethereum mining, the steady increase in difficulty and hash rate compared to other years seriously affected the monthly earnings. In the 10 graphics cards used in 2019 data, electricity consumed per card was 150 watts, daily electricity was 43.2 kW/h, annual 518.4 kW/h, and annual revenue was 1288.08 US Dollars. When the data is examined, the difficulty level and hash rate, which increases in direct proportion to the demand for Ethereum mining, seriously affected the earnings of the miners. The system that started mining in 2017 to generate the same income in other years, new graphics cards should be added to the system and as a result, the electricity consumption should increase at the same rate. The degree of difficulty and the hash rate of a virtual currency varies depending on the number of miners involved in the pool and the transaction volume of the virtual currency involved. The increase of

these two criteria is observed in direct proportion to the more energy consumption of the systems trying to provide the same gain.

Discussion

Energy consumption of cryptocurrency mining is a very controversial topic. There are various estimations. However, these estimations vary considerably from study to study. The mining process of any cryptocurrency contains many costs, equipment, facilities, labor, and electricity. Based on the electricity consumption some countries used their geographical advantage and become a cryptocurrency state or country. As mentioned in the literature, energy consumption is the most dangerous problem for all cryptocurrencies since some production farms produce cryptocurrency but consume more energy even more than houses during the production phase. Many researchers aimed to calculate and minimize energy consumption. But it is still quite hard to minimize or prevent the consumption of electricity in the mining process of any cryptocurrency version.

In this study; Ethereum was used in an experiment to analyze energy consumption. The experiment examined the data from 2017 to 2019. These data were compared with another popular cryptocurrency which is bitcoin to find the better one for the environment. In this study, the data from 196 GPUs were examined and electricity consumption and gain were analyzed. 3 different types of GPU brands were used, and the brand of the units, the power consumed, and the electricity unit price in the country where it was tested were analyzed respectively.

Energy consumption is the most dangerous problem for all cryptocurrencies because some production farms produce cryptocurrencies, but they consume even more energy from home during the production phase. In case of excessive consumption, it harms the environment while not bringing any profit to the investor. In the literature, researchers have applied some green technology methods to find the consumption rate and solve the consumption problem. In the literature, many researchers have tried to analyze energy consumption with several studies. Researchers have used various hardware types and high-efficiency machines with different scenarios in their experimental studies. The researchers calculated the total energy consumption based on the equipment used in the mining process.

Along with the findings in the literature, this study addresses the issue of energy consumption from cryptocurrency mining. The findings will be useful for the development of cryptocurrency management and blockchain, especially in terms of energy policies regarding cryptocurrencies. The results show that energy consumption is still a major issue with cryptocurrencies.

It is almost impossible to make a precise estimation of the energy consumption of cryptocurrency mining. Because the cryptocurrency prices directly affect mining and hence energy consumption. This study claims the maximum and minimum estimations of theoretical boundaries of the energy consumption of Ethereum mining. However, regularly, more efficient devices are introduced in the market almost every month. It is hard to predict the future efficiencies of the devices that manufacturers will introduce (Küfeoğlu and Özkuran, 2019, s. 101273).

Conclusion

Considering that today there are more than 4000 virtual currencies, trillions of transaction volumes, and billions of dollars of money volume; thousands of graphics cards used by thousands of miners who play a major role in the process of virtual currencies and solving algorithms consume trillions of kilowatts/hours of electrical energy. Therefore, the electrical energy consumed for virtual money mining increases gradually throughout the world and as a result, unless it is supported by renewable energy, it will reach a level that can be among the causes of

global warming. Considering this expenditure and a miner's need for more powerful interfaces than a normal computer, the average power supply required in a ring system of approximately 10 is 750-1300 watts. In today's technology, the electrical energy consumed by GPUs used in the sectors that do business with players and graphics operations is between 200-270 watts, and this rate causes serious electricity consumption.

In this study, 3 different brands of Graphic Processing Unit Series, namely AMD Radeon RX 580, Asus P106-100 Mining 6GB, Sapphire Radeon RX 580, a total of 196 Graphics Processing Units, Corsair HXi Series, HX1200i, Corsair HXi, AX1500i. 2 different power supplies, 38 power supplies, 196 Boosters, 8 GPU ASUS ROG STRIX Z270E GAMING LGA1151, 13 GPU ASRock Super Alloy H110 Pro, 20 motherboards in total, 20 Intel Pentium Dual Core 4400 Processors, 20 Kingston 8 GB ram, 'simple mining' Online Linux mining operating system, 20 flash memory and 20 aluminum and wooden cases, 38 electricity meters were used.

As a conclusion, this study addressed the issue of energy consumption from cryptocurrency mining. The findings in this study will be useful for cryptocurrency management and blockchain development, especially for energy policies concerning encrypted currencies. As shown in the results, energy consumption is still an immense problem in cryptocurrencies.

Future Recommendations

Cryptocurrency is a relatively new combination of cryptology and currency in financial areas and is increasingly frequently used worldwide. However, there is a lack of studies covering the power usage of digital currencies. In this paper, the general aspects of energy consumption and environmental effects of cryptocurrency mining technology are considered. For the data mining equipment, the main technical specifications defining its energy efficiency are analyzed. Results showed that energy consumption is still a big problem for the mining process.

Finally, one more crucial highlight is that by the year 2028, 98.44% of all Bitcoins will be produced. The discussion about the energy consumption of Bitcoin mining is likely to persist until then. But other cryptocurrencies like Ethereum are still a problem in energy consumption.

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