

Cryptocurrency and its Effect on the Electric Grid

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Abstract. Since the anonymous person or group known as Satoshi Nakamoto created Bitcoin in 2008, interest in the cryptocurrency has grown exponentially. In the past 14 years, thousands of additional cryptocurrencies have been created, some still active while others have faded into obscurity. Investors have flocked to cryptocurrencies for a variety of reasons from technology to decentralization to a hedge against inflation to simply chasing profits. For all the proponents that Bitcoin and other cryptocurrencies have, they also have their share of critics. Recently, many people around the world have criticized cryptocurrencies for the amount of energy that they consume for new coins to be mined. This article aims to assess current data regarding energy usage for mining cryptocurrencies as well as, understand what actions are being taken to reduce the carbon footprint of these cryptocurrency mining activities around the world.

Key words. Cryptocurrency, Proof of Work, Proof of Stake, Electric Grid, Energy Usage

1. Introduction

The biggest issue surrounding digital payment methods is the need for a method to prevent “double spending,” or spending money that is not really in one’s account, but is listed there due to the existence of multiple ledgers with different amounts listed. Bitcoin was created to function as a single ledger for all transactions while being decentralized; meaning, no centralized power or authority is needed or could oversee and manage it. The secret to cryptocurrencies and their security as well as, their need to consume large amounts of energy is the method by which new blocks are verified and created through the use of

cryptography. Cryptography is the art and science of encrypting sensitive information [1].

Cryptocurrency was born in the early 1980s when e-Cash was conceived. Although cryptocurrency is seen as “new,” it has a few decades of history. Some of the most common currencies include Bitcoin, Ethereum, Litecoin, Cardano, and Polkadot. The cryptocurrency world stayed relatively quiet until Bitcoin was created in 2008 by Satoshi Nakamoto. Since then, the idea of cryptocurrency has really taken off (Fig. 1). A few years later, starting around 2011, competitors to Bitcoin began to emerge, as the market grew bigger. Between then and when the Ethereum platform was created, Bitcoin crashed and ran into some theft issues [2]. From the point that the Ethereum platform emerged, the values of most cryptocurrencies have skyrocketed and continued the uptrend where Bitcoin has recently broken the USD 46,500 price. The current outlook for cryptocurrencies shows no downturn coming anytime soon.

There are two main types of cryptocurrencies. Bitcoin is considered the original cryptocurrency and is held in a category all its own. Altcoins are short for alternate coins to Bitcoin, which have a use and are beneficial in some way.

The acceptance of cryptocurrencies has vastly grown over the past few years. Though this is generally the case in most regions, some countries do not allow the use of cryptocurrencies:

- China
- Russia
- Vietnam

- [illegible]

Even though cryptocurrencies have been around more than 10 years, many countries do not have the systems to regulate the currency. In many countries crypto is generally a “grey area” with regard to regulations and it is up to individual companies to decide if they would like to accept it (Fig. 2). As of July 2020, using cryptocurrency as a payment method is illegal in Russia [5]. Many countries are concerned about citizens using cryptocurrencies as it is relatively new, somewhat difficult to track, and has little or no laws nor regulations related to it within many societies. These issues make crypto usage and acceptance very difficult. In some countries like the USA, Canada, and the UK, mining and using cryptocurrencies are virtually unregulated.



The strictest stance of any country in the world is China's outright blanket ban of all cryptocurrency related activities as of September 2021 [6]. This ban includes all forms of cryptocurrency trading and financing, and the People's Bank of China (PBOC) prohibited all outside cryptocurrency exchanges from offering their services to Chinese citizens [6]. Most believe this crackdown regarding cryptocurrencies for their citizens is to pave the way for the PBOC to implement their state-backed digital currency to replace paper and coin money in the country.

Various software are currently being used for cryptocurrencies. The choice of software depends on the tools and features that are needed for the specific rig. Some popular software include:

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The different software tools all use the same algorithms but where they differ is how they implement the different algorithms. Like that of the different types of hardware, each software has its pros and cons and depends on the end users and their needs from the software.

There are three different types of hardware used for cryptocurrency mining (Fig. 3):

Application Specific Integrated Circuit (ASIC) describes a type of hardware that is designed with a specific mining application in mind. This type of mining can offer hashrate speeds that are drastically higher than that of a general CPU. The one downside to this is that the chips are designed for a specific hashing algorithm and must be bought for very specific applications. Another downside to this hardware is that it is generally the most expensive of the three options for hardware [9].

Graphics Processing Unit (GPU) has been developed using the hardware used for normal graphics processing in a computer. This gives the user of a gaming computer the ability to begin mining. Though this began as a cheaper way to mine, the popularity of it has driven up the price of these graphics cards and has made them more difficult to obtain even if you are not planning to do mining with them. Though they can be more difficult to find, GPUs give the user much more flexibility to mine different currencies as well as even use the GPU for its original intended purpose when not mining [9].

Field-Programmable Gate Arrays (FPGA) are a composition of integrated circuits designed ground up for cryptocurrency mining. As these have a dedicated use similar to that of an ASIC miner, they are able to perform similarly compared to a GPU. Where the FPGA hardware stand out is in their power consumption as they use drastically less power compared to a GPU.

Each of the three types of mining hardware have their preferred use, as well as, pros and cons, such as: power consumption, use on single or multiple types of cryptocurrencies, or even having the opportunity to be used outside of cryptocurrency mining. Choosing the right type of hardware depends on the user's intentions on how the equipment will be used [9].

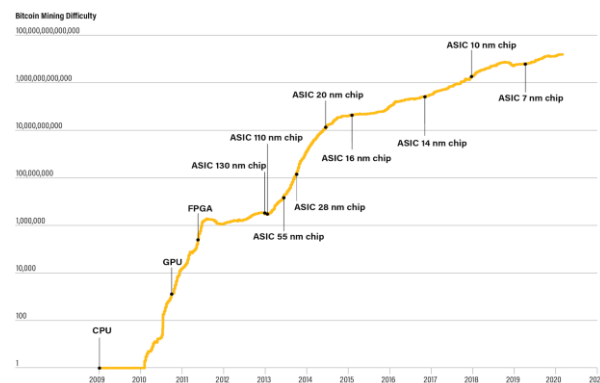


Fig. 3. Bitcoin mining difficulty vs. time and approximate introduction dates of new mining technology [10]

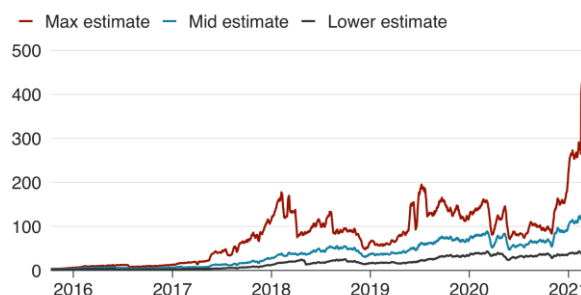
One of the issues with the hardware used for cryptocurrency mining is that the technology is constantly evolving, improving and has a fairly short lifespan. Researchers estimate Bitcoin mining devices have an average lifespan of only 1.29 years [11]. Not only is this generally wasteful, it also contributes to the current and ongoing chip shortage in electronics manufacturing. With a constant turnover of electronic devices, it has been estimated that only about 17% of the waste from these devices is recycled at the end of their use cycle. With the combination of the equipment and recyclability, the current trends in Bitcoin are not environmentally and commercially sustainable or for more than a few years, hence making it especially difficult for some to keep up with the constant monetary demand of the business.

3. Energy Consumption Debate

The processes associated with mining cryptocurrency are inherently very energy intensive, similar to modern gaming computers in the US (Fig. 4). Bitcoin currently consumes around 110 TWh per year — 0.55% of global electricity production, or roughly equivalent to the annual energy draw of small countries like Malaysia or Sweden [12]. The above is not including the various other types of crypto besides Bitcoin (Fig. 5). A rig with three GPUs can consume 1,000 Watts of power or more when it is running, the equivalent of having a medium-size window AC unit turned on [13].

Estimates for bitcoin's electricity consumption

Annualised terawatt hours (TWh)



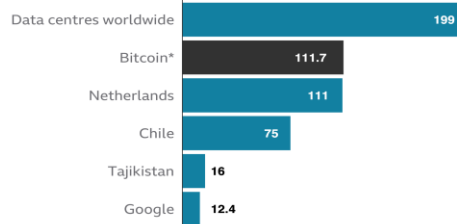
Note: Based on assumption that average cost paid by miners worldwide is \$0.05/kWh

Source: Cambridge Centre for Alternative Finance

Fig. 4. Estimates for Bitcoin's electricity consumption [14]

Bitcoin consumes a 'similar amount of power to the Netherlands'

Annual power consumption, in TWh



*All figures 2019 except Bitcoin, which is annualised middle estimate for bitcoin electricity consumption in January 2021

Source: Forbes, IEA, EIA, Cambridge Centre for Alternative Finance

Fig. 5. General overview of Bitcoin energy consumption compared to countries with a similar energy consumption [14]

One of the rising concerns with cryptocurrency is that there is, as noted above, a large amount of energy consumed during its mining. Associated with this consumption, weak energy grids are highly prone to blackouts. This is becoming a problem in various countries around the world. Bitcoin mining has had an effect on energy consumption and the electric grid in many countries such as Kazakhstan and Venezuela to name a few. A rapid increase in Bitcoin mining has caused blackouts and power shortages in these areas.

During the recent and ongoing financial crisis in Venezuela, many people have resorted to Bitcoin mining in order to have some income. Heavily subsidized electricity makes Bitcoin mining in Venezuela highly profitable, which results in power shortages [15]. To combat weak power grids, many miners have setup close to or even within power generation sites (e.g., hydroelectric plants, wind farms, and coal burning plants). This can be beneficial especially with renewable sources because in certain cases the amount of energy being produced at a given time cannot be completely used. It is estimated that in 2019, on average, 39% of PoW mining was powered by renewable energy, compared to the global average of 25% of electricity generation coming from renewable energy sources [16]. Table I shows the breakdown of global renewables penetration in Bitcoin mining.

Table I. - Breakdown of Global Renewables Penetration in Bitcoin Mining [17]

| Region | Global Mining Share | Renewables Penetration | Share of Renewables for Mining | Share of Fossil/Nuclear for Mining |
|--------------------------|---------------------|------------------------|--------------------------------|------------------------------------|
| Sichuan | 48.0% | 90.1% | 43.2% | 4.8% |
| Relevant Remaining China | 12.0% | 47.1% | 5.7% | 6.3% |
| Relevant Western Regions | 35.0% | 79.4% | 27.8% | 7.2% |
| Rest of the World | 5.0% | 18.2% | 0.9% | 4.2% |
| Global Total | 100% | | 77.6% | 22.4% |

Sources: Deutsche Bank Research, Chinese National Energy Agency, Morgan Stanley Research, EIA, CoinShares Research

Setting up mining operations close to or within power generation sites is a very common practice in different climate zones in Asia. For example, many cryptocurrency miners would strategically place their facilities on a grid that runs off of hydroelectric power. In this case, during the wet season they would affect the grid in a minor way. They just use the excess energy produced by the hydroelectric facility. Using these renewable resources is another way to offset the impact on the grid. Geothermal power is being used to mine Bitcoin in El Salvador [18]. The country loses large amounts of geothermal energy during energy transportation to cities or from oversupply of energy and lack of storage. Iceland is a similar country with plenty of geothermal energy for use.

In addition to lowering the strain on the power grid, the use of renewable energy during cryptocurrency mining also lowers the associated carbon footprint. The carbon footprint of cryptocurrency mining is difficult to estimate. Because of the competitive nature of this industry, there is also secrecy amongst many of the different associated operations.

Some of the most recent studies show that the cryptocurrency mining industry averages close to 39% renewable energy use, which is better than the power grid in the US by a factor of 2. Though these studies are taking data from some of the largest corporations in the business, many smaller companies are also setting up shop close to renewable energy resources.

4. Future Outlook for Digital Currencies

As more and more general consumers have started investing in cryptocurrencies, it has also garnered institutional attention. Many large companies have begun to buy Bitcoin to hold on their balance sheets in amounts from 1 to 5% of the total value of the company's holdings. These companies include such names as Tesla, MicroStrategy, Square Inc. and Time Magazine. This demonstrates that companies are seeing cryptocurrency as something that is here to stay and less of a highly speculative investment [19].

Beyond companies adding cryptocurrency to their balance sheets, some companies have created options for paying with cryptocurrencies. While most of these companies accept Bitcoin, some of them have more diverse options, including Ethereum, Litecoin or even Dogecoin. Some major companies that are accepting cryptocurrencies as payment are Microsoft, Overstock, Home Depot, Namecheap, Starbucks, Whole Foods, and NewEgg [20]. Some say that these companies are accepting cryptocurrency payments in order to appeal to younger consumers, while others argue that it is for publicity.

All the attention on cryptocurrencies and the mainstream focus they are garnering is causing governments across the world to take notice. Some governments have passed legislation to regulate the exchanges on which cryptocurrencies can be bought. Others have been very noncommittal about whether they will support or discourage cryptocurrency usage. Still others are trying to push their own national cryptocurrencies, with countries such as China and the Bahamas already issuing their own digital currencies. Others, like South Africa, India, Pakistan, and Thailand, have formed definite plans to implement their own cryptocurrencies but have not acted on those plans as of yet. Beyond that, over 20 other countries are credited as "exploring digital currency" during 2021 [21]. Many countries are trying to play it safe and look into what digital currencies would entail for their nation's future. As it stands today, countries exploring digital currency options bodes well for cryptocurrencies as a whole as the concept of digital currency becomes more and more mainstream.

5. Conclusions

Overall, cryptocurrencies are not going to falter, and adoption will continue to increase [22]. Even when countries have banned exchanges, citizens will either leave the country or use workarounds like VPNs to continue to take part in the cryptocurrency environment. For many, cryptocurrency solves the very real problem of high inflation, destroying wealth in many countries with rapidly devaluing currencies. Additionally, more and more companies are supporting Bitcoin and other cryptocurrencies by either adding them to their balance sheets or accepting various cryptocurrencies as payment for goods or services rendered. This all speaks to cryptocurrencies being a force that is here to stay, though which particular cryptocurrencies will withstand the test of time and be in usage 20 years from now is anyone's guess.

Although Bitcoin and other cryptocurrency mining does consume a lot of energy, many steps are being taken to improve on this without hindering electrical grids across the world. With many PoW cryptocurrency miners setting up their mining operations near renewable energy sources to consume primarily excess energy that would otherwise go to waste, the cryptocurrency community is aware of the criticisms and is actively working to address them. Beyond this, with the rise in PoS cryptocurrencies that consume considerably less energy than PoW cryptocurrencies, the cryptocurrency community is trending towards more responsible energy usage and sustainability.

Most studies do not even consider the carbon footprint of banking with fiat currency, and the energy consumed by tens of thousands of brick and mortar bank branches across the world. Is it really that much of an energy consumption difference if we could make all those disappear?

References

- [1] Mardisalu, R., "Introduction to Cryptography," Accessed 3 Jan. 2022, [Introduction to Cryptography: Simple Guide for Beginners - TheBestVPN.com](#)
- [2] Marr, B., "A Short History Of Bitcoin And Crypto Currency Everyone Should Read," Forbes, Accessed 3 Jan. 2022, [A Short History Of Bitcoin And Crypto Currency Everyone Should Read \(forbes.com\)](#)
- [3] Carlos, J., "Visualizing Bitcoin's Wild Ride in the Last Decade," HowMuch, Accessed 3 Jan. 2022 [Visualizing Bitcoin's Wild Ride in the Last Decade \(howmuch.net\)](#)
- [4] Agrawal, H., "Is Bitcoin Mining Legal? Regulations From Around The World," CoinSutra, Accessed 3 Jan. 2022, [Is Bitcoin Mining Legal? Regulations From Around The World \(coinsutra.com\)](#)
- [5] Rees, K., "10 Countries Where Cryptocurrency Is Illegal or Restricted," 3 Nov. 2021, Accessed 3 Jan. 2022, [10 Countries Where Cryptocurrency Is Illegal or Restricted \(makeuseof.com\)](#)
- [6] Baccardax, M., "China Issues Blanket Ban On Cryptocurrency Trading; Bitcoin, Coinbase, Robinhood Slide," TheStreet, 24 Sep. 2021, Accessed 3 Jan. 2022, [China Issues Blanket Crypto Trading Ban; Bitcoin, Coinbase Slide - TheStreet](#)
- [7] Qadir, AK, "Proof of Work (POW)- What it is & How it Works," Coinpedia, 3 Oct. 2020, Accessed 3 Jan. 2022, [Proof of Work \(POW\)- What it is & How it Works | Coinpedia](#)
- [8] "Proof of Stake (PoS) in Blockchain," GeeksforGeeks, 11 Dec. 2019, Accessed 3 Jan. 2022, [Proof of Stake \(PoS\) in Blockchain - GeeksforGeeks](#)
- [9] Ramsey, B., "The Impressive Hardware Used in Cryptocurrency Mining," Medium, 20 Jun. 2018, Accessed 3 Jan. 2022, [The Impressive Hardware Used in Cryptocurrency Mining | by Bradley Ramsey | Supplyframe | Medium](#)
- [10] Kim, C., "The Rise of ASICs: A Step-by-Step History of Bitcoin Mining - Coindesk," 26-Apr-2020, Accessed 3 Jan. 2022, [The Rise of Specialized Mining Equipment on Bitcoin - CoinDesk](#)
- [11] "Bitcoin mining producing tonnes of waste," BBC News, 20 Sep. 2021, Accessed 3 Jan. 2022, [Bitcoin mining producing tonnes of waste - BBC News](#)
- [12] Carter, N., "How Much Energy Does Bitcoin Actually Consume?," Harvard Business Review, 5 May 2021, Accessed 3 Jan. 2022, [How Much Energy Does Bitcoin Actually Consume? \(hbr.org\)](#)
- [13] Gonzalez, O., "Here's how much electricity it takes to mine Bitcoin and why people are worried," CNET, 31 Aug. 2021, Accessed 3 Jan. 2022, [Here's how much electricity it takes to mine Bitcoin and why people are worried - CNET](#)
- [14] Rowlett, J., "How Bitcoin's vast energy use could burst its bubble," BBC News, 27 Feb. 2021, Accessed 3 Jan. 2022, [How Bitcoin's vast energy use could burst its bubble - BBC News](#)
- [15] Malviya, H., "Surge in Bitcoin Mining in Venezuela Causes Blackouts," itsblockchain, 23 Dec. 2017, Accessed 3 Jan. 2022, [Surge in Bitcoin Mining in Venezuela Causes Blackouts | ItsBlockchain](#)
- [16] "Cryptocurrency mining and renewable energy: Friend or foe?," Smart Energy International, 25 May 2021, Accessed 3 Jan. 2022, [Cryptocurrency mining and renewable energy: Friend or foe? \(smart-energy.com\)](#)
- [17] Redman, J., "Bitcoin energy consumption is far more efficient and greener than today's banking system," Mining, Bitcoin News, 19 Jan. 2021, Accessed 3 Jan. 2022, [Bitcoin Energy Consumption Is Far More Efficient and Greener Than Today's Banking System - Mining Bitcoin News](#)
- [18] Gans, N., "El Salvador President Calls For A Volcanic Geothermal Bitcoin Mining Plan," Forbes, 9 Jun. 2021, Accessed 3 Jan. 2022, [El Salvador President Calls For A Volcanic Geothermal Bitcoin Mining Plan \(forbes.com\)](#)
- [19] Katje, C., "These Big Money Players Have Put Bitcoin On The Balance Sheet," Benzinga, 20 Apr. 2021, Accessed 3 Jan. 2022, [These Big Money Players Have Put Bitcoin On The Balance Sheet | Benzinga](#)
- [20] Tuwiner, J., "Who accepts Bitcoin? 11 major companies," 20 Dec. 2021, Accessed 3 Jan. 2022, [9 Major Companies Who Accept Bitcoin | Spend Crypto 2022 | buybitcoinworldwide.com](#)
- [21] Buchholz, K., "China First Major Economy to Issue Digital Currency," Statista, 6 Apr. 2021, Accessed 3 Jan. 2022, [Chart: China First Major Economy to Issue Digital Currency | Statista](#)
- [22] Ray, S., "Tesla Will Accept Dogecoin Payments For Some Products And 'See How It Goes,' Says CEO Elon Musk," Forbes, 14 Dec. 2021, Accessed 3 Jan. 2022, [Tesla Will Accept Dogecoin Payments For Some Products And 'See How It Goes,' Says CEO Elon Musk \(forbes.com\)](#)