



# Sustainability and Environmental Impact of Mining and Maintaining Cryptocurrencies: A Review

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## ABSTRACT

Cryptocurrency has seen an increased popularity with the introduction of Bitcoins. It has been adapted in several countries and has become an alternate solution to conventional currency. Despite its benefits, some controversies surround the manufacturing of bitcoins. While all the countries are moving to sustainability development and global warming control, Bitcoin production has raised several concerns about environmental pollution and sustainability. The increased carbon emissions and high electrical consumption have accompanied the popularity of cryptocurrency. Hence, there is an immediate need to reduce the carbon footprint and electricity consumption caused by human cryptocurrency for a sustainable future. This study presents the current scenario and trends of worldwide cryptocurrency growth and discusses the environmental impact of cryptocurrency mining. It explores crypto mining worldwide and provides a qualitative review. Further, this article highlights the need to take necessary measures to control cryptocurrency circulation.

## INTRODUCTION

In the past few years, a wide variety of electronic or digital currencies called cryptocurrencies that serve as means for commerce have grown firmly. Many countries are showing interest in using or generating cryptocurrency to gain the benefits early. The sustainability aspect of cryptocurrency has become a major concern as it contributes to the environmental effects (Corbet et al. 2020); an increase in global crypto mining activities increases greenhouse gas emissions and requires a large water footprint (Siddik et al. 2023). The cryptocurrency mining process is highly complicated, and it involves the use of specialized machines that store the transaction information in decentralized digital blockchains. The increase in computational power requires large electricity in the generation of cryptocurrency. However, the growing energy consumption produces huge carbon emissions and poses harm to the environment. Electronic waste (E-waste) generation is another major factor in cryptocurrency mining. E-waste increases the risk to the environment by releasing harmful substances into the soil and making the air polluted. Further, the inadequate recycling process will contribute to water pollution. This report aims to discuss the environmental impact of cryptocurrency mining

and compare it to the benefits it will provide to society and the economy.

## KEY FINDINGS AND ANALYSIS

Cryptocurrency represents an alternate form to traditional currency by identifying its qualities and advantages of using and considering the impact on the environment. The sustainability of Cryptocurrency has become a challenge owing to its rising environmental consequences regarding energy usage and increasing carbon footprint. Cryptocurrency mining generates vast amounts of electronic waste, carbon dioxide, and fossil fuels (Wendl et al. 2023). It states that with the increase in the power consumption for the mining process, the carbon emissions linked with this technology pose a significant concern.

Further, the pollution produced by cryptocurrency mining, the use of renewable energy, and the knowledge of environmental damage produced by cryptocurrency mining will all help to solve the sustainability issue (Alonso et al. 2021). As mentioned by (Badea & Mungiu 2021), the study suggests that Bitcoin is still widely used in the economy for several reasons despite its considerable use of energy and adverse impact on the environment. Therefore, the benefits

that the cryptocurrency offers and its sustainability depend on energy consumption during the mining process and various aspects that impact the environment during its production and usage.

**ENERGY CONSUMPTION**

The growing use of cryptocurrency and increased crypto mining activities require more electric energy for the generation. As per the energy consumption report of (Raynor 2023a), the bitcoin energy consumption recorded an estimated maximum value of up to 204.5 Terawatt-hour (Twh) during early 2022. According to the estimates for the year 2018, bitcoin consumed at least 40.0 TWh and as much as 62.3 TWh of electricity. In May 2023, bitcoin mining had an estimated electrical energy consumption of 95.58 Twh. It recorded its greatest annual electricity consumption in 2022, reaching at 204.5 terawatt-hours, exceeding the Finnish power usage. The global energy consumption of bitcoin has significantly increased from the year 2017 to

2023 (see Fig. 1) (Raynor 2023a). Hence, it can be realized that energy consumption also increases with the increase in crypto mining.

Furthermore, according to (Raynor 2023b), in the visualization of percentage share by several countries towards the bitcoin energy consumption; it can be noticed that the Czech Republic contributes about 136.7% of energy share powered by bitcoin (see Fig. 2). It can be observed that some of the big nations, such as the USA, UK, Australia, Russia, and Canada account for the bitcoin power in the total energy consumption. For example, The United States is projected to house over one-third of the global crypto mining activities, which now consume 0.9% to 1.7% of total U.S. power consumption.

The trends from the Bitcoin power share indicate there is a potential growth in the electricity demand for crypto-asset operations. Many big countries are involved in crypto-mining activities and contributing electrical energy share to bitcoin generation (see Fig. 2) (Raynor 2023b). From

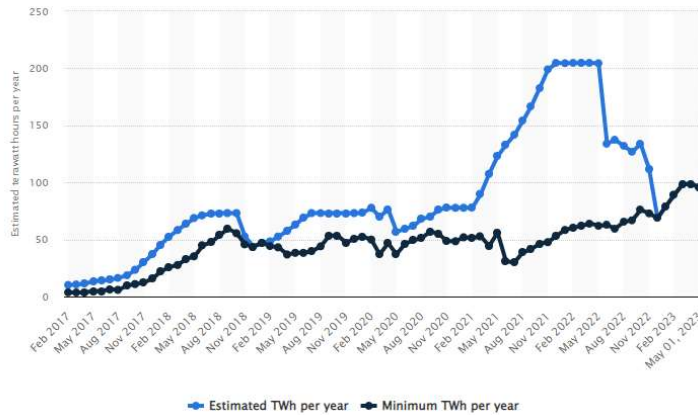


Fig. 1: Bitcoin energy consumption worldwide (Raynor 2023a).

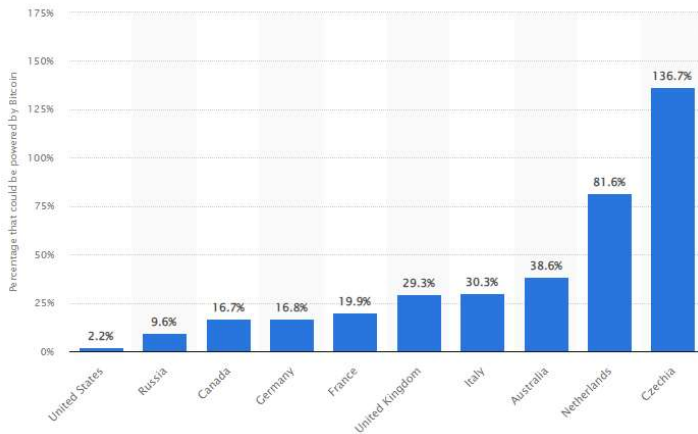


Fig. 2: Global bitcoin energy consumption share by countries (Raynor 2023b).

this perspective, it is worth noting that the electrical energy requirements across several nations vary significantly due to the increase in the share of Bitcoin energy consumption.

In this regard, the University of Cambridge deployed an online tool to assess the global Bitcoin energy consumption across various countries and measures the Bitcoin Electricity Consumption Index (University of Cambridge 2023). According to the online tool, Bitcoin consumes more power than Norway (122.20 TWh), the Netherlands (108.8 TWh), the United Arab Emirates (113.20 TWh), and Argentina (121 TWh). It claimed that the energy it consumes could run every microwave in the United Kingdom for 27 years. It also implies that the total amount of electricity used annually on household appliances in the US could run the whole Bitcoin system for an entire year. According to a Cambridge

University estimate, Bitcoin uses more power per year than the entire country of Argentina (see Fig. 3) (University of Cambridge 2023). Therefore, the online tool from the University of Cambridge suggests that Bitcoin consumes more power annually than The Netherlands, Argentina, and the United Arab Emirates combined.

### ENVIRONMENTAL IMPACT

Bitcoin can significantly impact the environment with carbon emissions and may lead to global climate change. A visualization by (Bruna 2023) (see Fig. 4) shows that carbon dioxide emissions from bitcoin mining reached over 17.29 million metric tonnes, with the Inner Mongolia area of China accounting for about 26.2% of those emissions. This country was responsible for over half of the carbon

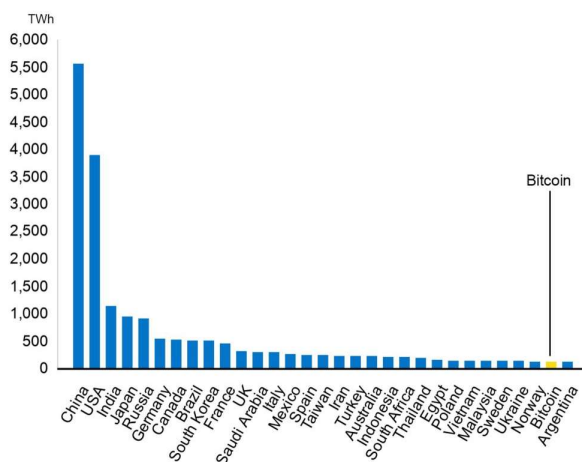


Fig. 3: Global bitcoin energy consumption by countries per year (University of Cambridge 2023).

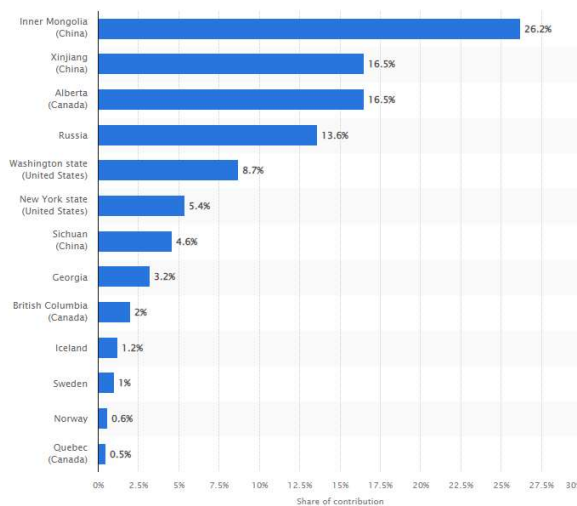


Fig. 4: Bitcoin mining carbon footprint worldwide (Bruna 2023).

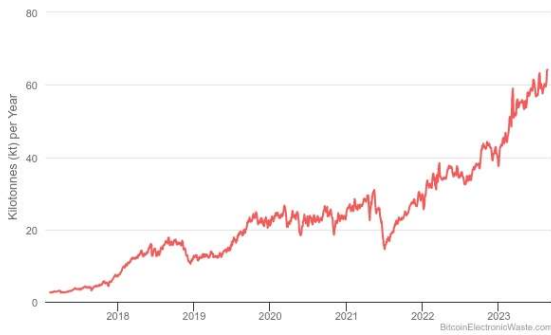


Fig. 5: Bitcoin electronic waste generation 2017–2023 (Alexander 2023).

footprint of Bitcoin mining worldwide. The calculations are based on the presumption that carbon emissions from power production remain constant across China; a nation that continues to dominate worldwide bitcoin mining. However, when the mining environment in China is broken down by area to account; it leads to a substantially lower projected global footprint for Bitcoin in 2018 of 17.29 megatons of CO<sub>2</sub>. The fact that Inner Mongolia, which relies heavily on coal, produces 12.3% of all Bitcoins mined, or an enormous 25% of all emissions, reflects these variations. Therefore, with the increase in global Bitcoin energy consumption, CO<sub>2</sub> emissions have risen significantly.

The growing electronic waste from bitcoin generation poses a threat to the environment; including issues like pollution due to harmful substances and metals. According to (Digiconomist 2023), the generation of electronic waste related to Bitcoin for 2017–2023 is illustrated. It is found that a predicted 2.9 million active devices, which together weigh 39.75 metric kilotons, produce 30.7 metric kilotons of e-waste per year (see Fig. 5). E-waste as a whole constitutes an increasing risk to the environment, from harmful substances and metals that are leaking into soils caused by inadequate recycling; according to the environmental protection agency. A further statement is made to the effect that at peak Bitcoin price levels expected at the beginning of 2021, the yearly quantity of e-waste could go beyond 64.4 metric kilotons in the future. The quantity of electronic waste production currently amounts to 272 grams of e-waste

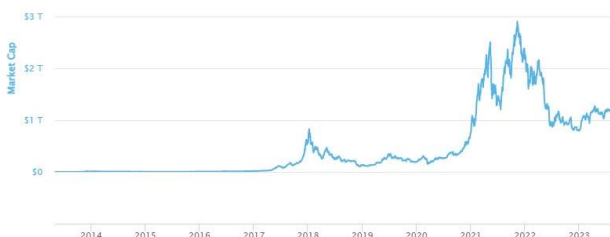


Fig. 6: Global cryptocurrency chart (Coinmarketcap 2023).

for each blockchain transaction. It claims that replacing the mining system entirely would be the best way to address this e-waste production. In this context, the electronic waste produced due to Bitcoin mining has dramatically increased, posing environmental concerns.

## CRYPTOCURRENCY MARKET TRENDS

The global cryptocurrency market is evolving, and the bitcoin circulation has significantly increased. The total consists of steady currencies and coins, and the market capitalization peaked in early 2022 (see Fig. 6) (Coinmarketcap 2023). Many cryptocurrency enthusiasts consider this a critical Bitcoin chart for comprehending the whole space. In addition, to demonstrate the existence of cryptocurrency, the graph depicts the historical quantity of bitcoin in circulation (see Fig. 7) (Statista 2024). It does not take into account lost bitcoins. Currently, there are 19,465,818.75 bitcoins in circulation. This value fluctuates every 10 minutes as fresh blocks are mined. At the moment, each new block contributes 6.25 bitcoins to the system. In this context, the bitcoin currency market capital and circulation have widely increased despite its environmental impact.

## EFFECTIVE MANAGEMENT

### Block Chain Technology

The growth in harmful greenhouse gas emissions across various regions worldwide raises questions about partnership and reliability. In this case, blockchain solutions show the potential way for nations to take necessary steps to ensure the impact on climate is low (Kamusalic et al. 2021).

### Low Energy Solutions

Blockchain also accelerates the use of renewable energy sources such as wind and solar, helping to create these

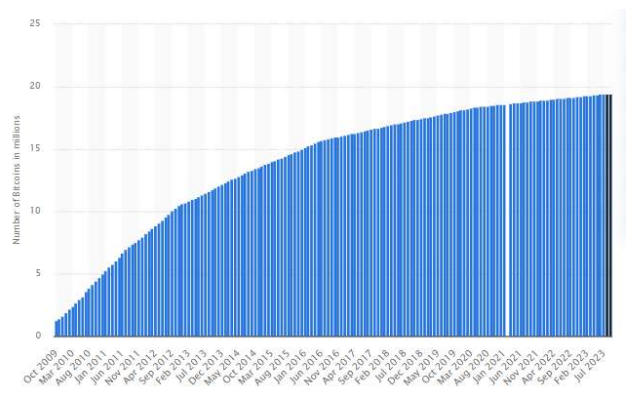


Fig. 7: Global Bitcoin Circulation (Statista 2024).

markets and further eliminate our dependency on fossil fuels (Sedlmeir et al. 2021).

### Investment on Climate

More financial investments are needed to slow down the rate of climate change. These investments could be further boosted if the global carbon markets rise.

### Monitoring Guidelines

Strong guidelines must be framed by national authorities; this setting is required to monitor crypto-assets continuously and may require timely changes. The authorities must possess the appropriate capabilities and resources to monitor the changing crypto asset ecosystem.

### CONCLUSIONS

Cryptocurrency, while accounting for a small fraction of economic transactions, is rapidly gaining acceptance as legal tender by significant businesses and governments. However, this exponential growth has raised serious concerns about its environmental impact. Our research reveals that the energy consumption, ecological footprint, and electronic waste generated by Bitcoin mining pose significant sustainability challenges. Using quantitative analysis, represented in graphs and charts, has allowed us to draw implications from large data sets, highlighting the alarming trend of increased electricity consumption for cryptocurrency mining between 2021 and 2022. This trend is global and varies significantly among countries, underscoring the urgent need for more sustainable practices in this sector.

Bitcoin mining, unfortunately, contributes to the expansion of the global carbon footprint and generates significant electronic waste. However, it is important to note that the circulation of Bitcoin currency has also drastically increased, with market capitalization reaching new heights in recent years. The environmental impact of the mining process is a clear challenge to sustainability, but it is not insurmountable. Like many commercially exploited factors, the perception of cryptocurrency extends beyond its environmental implications. Focusing on sustainable practices can pave the way for a more environmentally responsible future in the cryptocurrency industry.

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