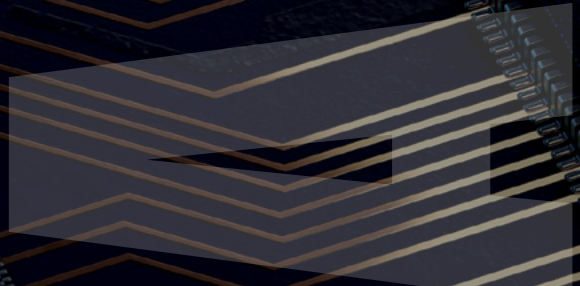
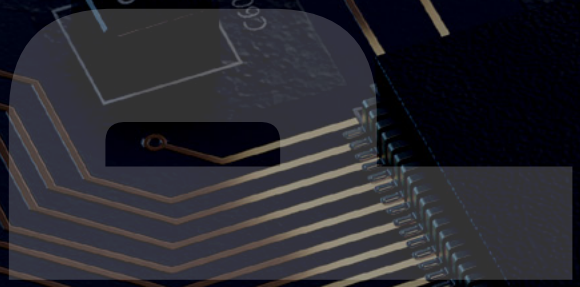
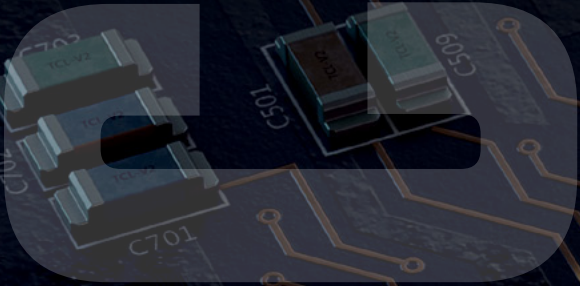


THE CAPCO INSTITUTE
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CRYPTO

Bitcoin's impacts on climate and the environment: The cryptocurrency's high value comes at a high cost to the planet

RENEE CHO

CLOUD

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DEAR READER,

Welcome to edition 55 of the Capco Institute Journal of Financial Transformation. Our central theme is cloud computing, which has transformed from an efficiency initiative for our clients, to an indispensable growth driver for financial services.

The pandemic has changed consumer expectations, with consumers now demanding 24/7 access to their financial resources from anywhere, as well as hyper-personalized products that reflect their lifestyle choices.

In this edition of the Journal, we explore the power of cloud and its potential applications through the lens of a joint Capco and Wipro global study, and take a deeper look at the financial services data collected in Wipro FullStride Cloud Services' 2021 Global Survey. The survey was focused on perceptions of cloud and its importance to business strategy from over 1,300 C-level executives and key decision-makers across 11 industries.

The study indicates that cloud is becoming ever more intelligent, hyperconnected, and pervasive, and enables companies to offer their end users the personalized, user-centric experience that they have come to expect. It's clear that only the financial services firms that can successfully leverage cloud, will thrive.

In addition, this edition of the Journal examines important topics around digital assets and decentralized finance, including central bank digital currencies, and bitcoin's impact on the environment, and cybersecurity and resilience.

As ever, you can expect the highest calibre of research and practical guidance from our distinguished contributors, and I trust that this will prove useful in informing your own thinking and decision-making.

Thank you to all our contributors and thank you for reading. I look forward to sharing future editions of the Journal with you.

A handwritten signature in black ink, appearing to read 'Lance Levy', with a stylized, flowing script.

Lance Levy, **Capco CEO**

BITCOIN'S IMPACTS ON CLIMATE AND THE ENVIRONMENT: THE CRYPTOCURRENCY'S HIGH VALUE COMES AT A HIGH COST TO THE PLANET¹

RENEE CHO | Staff Writer, Columbia Climate School, Columbia University

ABSTRACT

Bitcoin, with a market cap of U.S.\$727 billion, is the largest cryptocurrency in the world. It can be used to buy cars, furnishings, vacations, and much more. In 2011, one bitcoin was worth U.S.\$1; at the time of writing this article each bitcoin is worth approximately U.S.\$38,000. Because some bitcoin investors have become millionaires overnight, more and more people are intrigued by the possibility of striking it rich through investing in cryptocurrencies like bitcoin. But bitcoin's rising popularity may make it impossible for the world to stave off the worst impacts of climate change, because the energy consumption of this cryptocurrency is enormous and its environmental implications are far-reaching.

1. INTRODUCTION

In April of 2011, the price of one bitcoin was U.S.\$1; last November it reached an all-time high of almost U.S.\$68,000, and when this article was written, each one was worth approximately U.S.\$38,000. Because some bitcoin investors have become millionaires overnight, more and more people are intrigued by the possibility of striking it rich through investing in cryptocurrencies like bitcoin. But bitcoin's rising popularity may make it impossible for the world to stave off the worst impacts of climate change, because the energy consumption of this cryptocurrency is enormous and its environmental implications are far-reaching.

To understand bitcoin's environmental impacts, we first need to know what it is and how it works.

2. WHAT IS BITCOIN?

A cryptocurrency is a virtual medium of exchange that exists only electronically; it has no physical counterpart such as a coin or dollar bill, and no money has been staked to start it. R. A. Farrokhnia, Columbia Business School Professor and Executive Director of the Columbia Fintech Initiative,² said, "It's a marketplace and as long as people are willing to assign value to it, then that's it." Bitcoin, the largest cryptocurrency in the world, accounting for almost half of all cryptocurrencies,³ can be used to buy cars, furnishings, vacations, and much more. On February 21, 2022, bitcoin's market cap was U.S.\$727.05 billion.⁴

Cryptocurrencies are decentralized, meaning that there is no central authority like a bank or government to regulate them.

¹ Originally published by The Columbia Climate School's State of the Planet in September, 2021.

² <https://bit.ly/33HVUri>.

³ <https://bit.ly/319vQEz>.

⁴ <https://bit.ly/36xLtaT>.

The advantage of this is that there are no transaction fees, anyone can use it, and it makes transactions like sending money across national borders simpler. While transactions are tracked, the people making them remain anonymous. This anonymity and lack of centralized regulation, however, means that tax evaders, criminals, and terrorists can also potentially use cryptocurrencies for nefarious purposes.

Without physical money or a central authority, cryptocurrencies had to find a way to ensure that transactions were secure and that their tokens could not be spent more than once. Bitcoin was born in 2008 when a mysterious person (or persons) named Satoshi Nakamoto (whose true identity remains unknown), found a solution to these issues. Nakamoto's answer was a digital ledger system with trust in the system achieved through mathematics and cryptography, and with transactions recorded in blockchain. Blockchain is a transparent database that is shared across a network with all transactions recorded in blocks linked together. Nodes – powerful computers connected to the other computers in the network – run the Bitcoin software and validate transactions and blocks. Each node has a copy of the entire blockchain with a history of every transaction that has been executed on it.

Nakamoto capped the number of bitcoins that could be created at 21 million. While there is speculation about the math theories that led to the choice of that number, no one really knows the reason behind it. When this article was written, an estimated 19 million bitcoins were in circulation;⁵ it is expected that all remaining bitcoins will be released by 2140.

3. HOW DO BITCOINS ENTER CIRCULATION?

New bitcoins are released through mining, which is actually the process of validating and recording new transactions in the blockchain. The miner who achieves this first is rewarded with new bitcoin.

Miners must verify the validity of a number of bitcoin transactions, which are bundled into a block. This involves checking 20-30 different variables, such as address, name, timestamp, making sure senders have enough value in their accounts and that they have not already spent it, etc. Miners

then compete to be the first to have their validation accepted by solving a puzzle of sorts. The puzzle involves coming up with a number – called the nonce, for “number used once” – that when combined with the data in the block and run through a specific algorithm generates a random 64-digit string of numbers and letters. This random number must be less than or equal to the 64-digit target set by the system, known as the target hash. Once the nonce that generates the target hash is found, the winning miner's new block is linked to the previous block so that all blocks are chained together. This makes the network tamper-proof because changing one block would change all subsequent blocks. The result is broadcast to the rest of the blockchain network and all nodes then update their copies of the blockchain. This validation process, or consensus mechanism, is known as proof of work. The winning miner receives newly minted bitcoin as well as the transaction fees paid by the sender.

The higher the price of bitcoin, the more miners are competing, and the harder the puzzles get. The Bitcoin protocol aims to have blocks of transactions mined every ten minutes, so if there are more miners on the network with more computing power, the probability of finding the nonce in less than ten minutes increases. The system then makes the target hash more difficult to find by adding more zeroes to the front of it; the more zeros at the front of the target hash, the lower that number is, and the harder it is to generate a random number below it. If there is less computing power operating, the system makes the puzzle easier by removing zeroes. The Bitcoin network adjusts the difficulty of mining about every two weeks to keep block production to ten minutes.

Every 210,000 blocks, the bitcoin reward for miners is halved. According to Investopedia,⁶ when bitcoin was first mined in 2009, mining one block would earn 50 bitcoins. By November of 2020, the reward was 6.25 bitcoins, but as of March, 2022, the price was about U.S.\$43,000 per bitcoin, so a miner would earn about U.S.\$270,000 (6.25 x 43,000) for completing a block.

It is estimated that there are one million bitcoin miners operating and competing, though it is impossible to be sure because miners with less computing power of their own can join mining pools, which need not report how many active miners they have.

⁵ <https://bit.ly/35iiX8H>.

⁶ <https://bit.ly/3HcMlsu>.

"I have a suspicion that Nakamoto had the notion that everyone could be a miner – that you could mine with nothing more than your laptop," said Farrokhnia. "But as Bitcoin became more popular and more people got on the system and the rewards were actually worth money, you began to see the advent of these mining pools which significantly increased the difficulty level. This turned into a vicious cycle – an arms race – to have the most powerful computers, but then the more powerful hardware miners have, the more difficult it is to find the nonce."

This intense competition is where the environmental impacts of bitcoin come in.

4. BITCOIN'S ENVIRONMENTAL IMPACTS

4.1 Energy consumption and greenhouse gas emissions

The process of trying to come up with the right nonce that will generate the target hash is basically trial and error – in the manner of a thief trying random passwords to hack yours – and can take trillions of tries. With hundreds of thousands, if not more, computers churning out guesses, Bitcoin is thought to consume 707 kWh per transaction. In addition, the computers consume additional energy because they generate heat and need to be kept cool. And while it is impossible to know exactly how much electricity Bitcoin uses because different computers and cooling systems have varying levels of energy efficiency, a University of Cambridge analysis estimated that bitcoin mining consumes 121.36 terawatt hours a year.⁷ This is more than what Argentina consumes, or more than the consumption of Google, Apple, Meta, and Microsoft combined.

And it is only getting worse, because miners must continually increase their computing power to compete with other miners. Moreover, because rewards are continually cut in half, to make mining financially worthwhile miners have to process more transactions or reduce the amount of electricity they use. As a result, miners need to seek out the cheapest electricity and upgrade to faster, more energy-intensive computers. Between 2015 and March of 2021, Bitcoin energy consumption increased almost 62-fold. According to Cambridge University, only 39 percent of this energy comes from renewable sources,⁸ and that is mostly from hydropower, which can have harmful impacts on ecosystems and biodiversity.

In 2020, China controlled over 65 percent of the global processing power that runs the Bitcoin network; miners took advantage of its cheap electricity from hydropower and dirty coal power plants. In 2021, however, China cracked down on the cryptocurrency market and mining out of concerns about their financial risks and enormous energy consumption, which works against China's goal to be carbon neutral by 2060. As a result, many Chinese bitcoin miners are trying to move operations to other countries, like Kazakhstan, which relies mainly on fossil fuels for electricity, and the U.S. A number of U.S. states, such as Texas and Georgia, are eager to attract Chinese miners to boost their own economies. In addition, U.S. miners themselves are raising hundreds of millions of dollars to invest in bitcoin mining and converting abandoned factories and power plants into large bitcoin mining facilities.

One example of this is Greenidge Generation, a former coal power plant in Dresden, New York, which converted to natural gas and began bitcoin mining. When it became one of the largest cryptocurrency mines in the U.S., its greenhouse gas emissions increased almost ten-fold between 2019 and 2020. Greenidge plans to quadruple its mining capacity by 2022 and wants to convert more power plants to mining by 2025. While Greenidge pledged to become carbon neutral through purchasing carbon offsets,⁹ the fact remains that without bitcoin mining, the plant would probably not be running at all. Other polluting peaker plants – power plants that usually only run during peak demand for a few hours a month – are being taken over for crypto mining to run 24/7.

Earth Justice and the Sierra Club sent a letter to New York State's Department of Environmental Conservation urging it to reject the renewal of Greenidge's permit that would allow it to increase its greenhouse gas emissions.¹⁰ They also warned that there are almost 30 power plants in upstate New York that could potentially be converted to bitcoin mining operations; if this occurred, it could stymie New York State's efforts to eliminate virtually all greenhouse gas emissions by 2050.

Globally, Bitcoin's power consumption has dire implications for climate change and achieving the goals of the Paris Accord because it translates into an estimated 22 to 22.9 million metric tons of CO₂ emissions each year – equivalent to the CO₂ emissions from the energy use of 2.6 to 2.7 billion homes for one year.¹¹ If bitcoin grows in value – some analysts

⁷ <https://bbc.in/3K1gbrt>.

⁸ <https://bit.ly/34YWaTl>.

⁹ <https://bit.ly/3s7D6uK>.

¹⁰ <https://bit.ly/3LU7bG3>.

believe its price could hit U.S.\$100,000 in 2022 – mining could increase, resulting in even more emissions, unless more renewable energy is used.

4.2 Water issues and e-waste

Power plants such as Greenidge also consume large amounts of water. Greenidge draws up to 139 million gallons of fresh water out of Seneca Lake each day to cool the plant and discharges it some 30° to 50°F hotter than the lake's average temperature, endangering the lake's wildlife and ecology. Its large intake pipes also suck in and kill larvae, fish, and other wildlife.

Even if it one day becomes possible to run all bitcoin mining on renewable energy, its e-waste problem remains.¹² To be competitive, miners want the most efficient hardware, capable of processing the most computations per unit of energy. This specialized hardware becomes obsolete every 1.5 years and cannot be reprogrammed to do anything else. It is estimated that the Bitcoin network generates 11.5 kilotons of e-waste each year, adding to our already huge e-waste problem.¹³

5. NFTS

A new phenomenon – NFTs – has added to the environmental concerns about cryptocurrencies. These are non-fungible tokens – digital files of photos, music, videos, or other kinds of artwork stamped with unique strings of code. People can view or copy NFTs, but there is only one unique NFT that belongs to the buyer and is stored on the blockchain and secured with the same energy-intensive proof of work process. NFTs are selling for hundreds of thousands of dollars; Beeple, a digital artist, sold one NFT for more than U.S.\$69 million.

Ethereum, the second most popular cryptocurrency after bitcoin, creates the NFTs. The average NFT generates 440 pounds of carbon – the equivalent of driving 500 miles in a gas-powered car – producing emissions 10 times higher than the average Ethereum transaction. One digital artist estimated that the carbon footprint of an average NFT is equivalent to more than an E.U. resident's electricity consumption for a month. Some artists, concerned about NFTs' environmental impacts, are trying to raise awareness and look for more sustainable ways of creating them.

6. HOW CAN CRYPTOCURRENCIES BE MORE SUSTAINABLE?

Because the entire Bitcoin network has invested millions of dollars in hardware and infrastructure, it would be difficult for it to transition to a more energy efficient system, especially since there is no central oversight body. However, there are a number of projects seeking to reduce the carbon footprint of Bitcoin, and cryptocurrencies in general. Tesla CEO, Elon Musk, met with the CEOs of top North American crypto mining companies about their energy use. The upshot was the creation of a new Bitcoin Mining Council to promote energy transparency.¹⁴

The Crypto Currency Accord is another initiative,¹⁵ with over 250 supporters, whose goal is making blockchains run on 100 percent renewable energy by 2025 and having the entire cryptocurrency industry achieve net zero emissions by 2040. It aims to decarbonize blockchains through using more energy efficient validation methods, pushing for proof of work systems to be situated in areas where excess renewable energy can be tapped, and encouraging the purchase of certificates to support renewable energy generators, much like carbon offsets support green projects.

Ethereum is aiming to reduce its energy use by 99.95 percent by 2022 through transitioning to an alternative validation system called proof of stake, as a few smaller cryptocurrencies have done. Proof of stake does not require computational power to solve puzzles for the right to verify transactions. Rather, it works like a lottery. To be considered, potential validators stake their ethereum coins (ETH); the more they stake, the greater their chances of being selected randomly by the system to be the validator. Participants will have to stake 32 ETH (each was worth about U.S.\$2600 when this article was written) per validator opportunity, with multiples of 32 ETH for more chances. After a new block is accepted as accurate, validators will be rewarded with coins and keep the coins they staked. The system ensures security because if validators cheat or accept false transactions in the block, they lose their stake and are banned from the network. When the price of ETH rises, stakes become more valuable, and thus network security increases, but the energy demands remain constant. Some worry, however, that proof of stake could give people with the most ETH more power, leading to a less decentralized system.

¹¹ <https://bit.ly/3s86xgj>.

¹² <https://bit.ly/3v72x0Z>.

¹³ <https://bit.ly/34W1sPv>.

¹⁴ <https://bit.ly/3sUdcfT>.

¹⁵ <https://bit.ly/3sY5r67>.



“Blockchain is a highly customizable and flexible technology,” said Farrokhnia. “You could design it in any shape or form that meets your objective. So, for example, another proof of consensus mechanism is called proof of reputation: the more reputable you are, the more votes you have in validating things.” The proof of authority system relies on reputation and trustworthiness; blocks and transactions are verified by pre-approved participants who must reveal their true identities. A few cryptocurrencies use proof of coverage that requires miners to provide a service – for example, hosting a router in their home to expand the network.

Other ideas for greening cryptocurrencies involve moving bitcoin operations next to oil fields, where they tap waste methane gas that is usually flared, pipe it to generators, and use the power for bitcoin mining. Some bitcoin mining is moving to west Texas where wind power is abundant. Because there is sometimes more wind power than transmission lines can handle, bitcoin mining situated near wind farms can use their excess energy.

Farrokhnia said that while these ideas are theoretically possible, they may not be pragmatic. “Each of these ideas requires very high upfront capital expenditures,” he said. “And we know that interest in mining is predicated on the price of bitcoin itself, so you could have all sorts of truly expensive solutions that would aim to be more energy efficient, but as soon as the price of bitcoin were to drop below a certain threshold, all these projects would be [canceled] because they’re just not financially feasible. Who in reality would make those investments given the volatility in price of bitcoin and the uncertainty about the future of it?”

Farrokhnia’s hope for greener cryptocurrency lies in its evolution. He believes that cryptocurrencies cannot ignore environmental considerations if they want to gain wider adoption, and that newer and greener cryptocurrencies will eventually eclipse bitcoin.

“There’s a new generation of crypto coming on board,” Farrokhnia said.¹⁶ “They are going to move away from proof of work for a number of reasons, one of which is the environmental impact, because most of these are being created by young programmers. They’re certainly more environmentally conscious, and hopefully, they understand the impact of the work beyond whatever they’re building and will take into account the complexity of today’s world.”

7. CONCLUSION

It is essential that climate and environmental implications are considered and managed as cryptocurrencies gain in usage around the world. Today, we are on track for global temperatures to rise between 2.5°C and 4.5°C,¹⁷ which could result in catastrophic impacts. It is challenging enough to reduce the greenhouse gas emissions we currently generate – the world cannot afford to add to them.

¹⁶ <https://bit.ly/3H8TsrS>.

¹⁷ <https://go.nasa.gov/3sbGFAR>.

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