**Testimony Prepared for the New York State Assembly Hearing on Cryptocurrency Mining**

**Joint Hearing of the Standing Committees on Environmental Conservation, Energy, Science & Technology, and Climate Change**

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## Summary

Bitcoin and other decentralized cryptocurrencies that are meant to serve as mediums of exchange have a transaction validation process called "mining" that requires large amounts of computing power and electricity consumption. This is a wasteful process with no socially redeeming aspects, especially since Bitcoin has proven to be an inefficient medium of exchange.

Bitcoin's underlying technology, called blockchain, could have transformative effects on finance. But this technology can be developed distinctly of Bitcoin. Hence, limiting cryptocurrency mining operations will not inhibit technological innovations that could have widespread benefits in terms of democratizing finance by making low-cost digital payments and basic banking services available to unbanked and underbanked households. Furthermore, Bitcoin mining has detrimental environmental consequences with few offsetting economic benefits to regions where this mining is done.

## Bitcoin's transaction validation through Proof of Work

Bitcoin is a decentralized cryptocurrency. It was designed to enable transactions using only the digital identities of transacting parties (referred to as pseudonymity) and without using traditional central bank money or the help of a financial institution. In other words, anyone with a computer could conduct transactions without relying on paper currency or having a credit card or bank account, and without having to reveal their real identities.

Bitcoin's unstable value has, however, rendered it an unviable medium of exchange. Moreover, transactions using the cryptocurrency are slow and expensive. The Bitcoin network also cannot process large transaction volumes in a timely manner. While it has failed in its stated objective as a pseudonymous medium of exchange, Bitcoin has somewhat paradoxically turned into a financial asset. Since Bitcoin lacks intrinsic value, its adherents seem to believe that its scarcity is the basis for its high price. The algorithm that governs the process of creating the cryptocurrency posits a hard cap of 21 million Bitcoins (about 18.5 million have been created so far).

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Whatever the ultimate fate of Bitcoin as a financial asset, its underlying technology, called blockchain, is truly innovative. It allows commercial transactions to be consummated through a process called public consensus that relies on transparency—all transactions and account balances in "digital wallets" are posted on public electronic ledgers, with amounts and digital identities of transacting parties visible to anyone with an internet connection. Transactions are validated when a majority of computers on the network confirm the legitimacy of the transactions based on balances in users' digital wallets. Blocks of newly validated transactions and updated account balances are then sequentially "chained" to earlier blocks using computer code. These blockchains, in effect electronic ledgers, are maintained on a large number of computers around the world and synchronized in real time, making them tamper-proof and secure.

The validation of transactions on the Bitcoin network requires that the nodes (computers) that maintain the digital ledgers accept the transactions as authentic and legitimate. The process of achieving such consensus among the nodes is referred to as Proof of Work, and is executed through a process called mining. This involves solving numerical puzzles generated automatically by the Bitcoin algorithm. These puzzles can only be solved by brute force computing power. The first computer to solve a particular problem gets the privilege of validating a specific block of transactions. The successful miner's reward is in the form of a Bitcoin.

**Hardware**

Bitcoin mining was initially conducted on regular computers, with the processing power of the devices' central processing units (CPUs) determining the success rate of the miners that used them. It soon turned out that graphics processing units (GPUs), essentially graphics cards used in higher-end machines, were better suited for the computations needed for cryptocurrency mining. The rising pecuniary benefits of cryptocurrency mining then led to some advances in hardware that could be better optimized for this purpose.

Much of the mining of Bitcoin is now carried out by specialized devices called ASICs, or application-specific integrated circuits. ASICs are tailor-built machines containing computer chips designed with a single, specific purpose. An ASIC can be optimized to mine a cryptocurrency that is based on a specific cryptographic algorithm. Bitcoin ASICs can now be bought for a few thousand dollars, and prospective Bitcoin miners are known to buy these by the hundreds or thousands. In some cases, they set up mining pools that combine the resources of individual miners. Such pooled resources increase the probability of successful Bitcoin mining because the pool, with its increased power, has a better chance of being the first to solve the cryptographic problems. Needless to say, it takes a lot of power to run the computers, or clusters of computers, that calculate potential solutions.

**Environmental costs**

The process of mining for Bitcoin has major environmental consequences. Miners now require huge arrays of computers that suck up large amounts of electricity simply to try to be the first to crack the complex numerical problems that yield rewards in the form of Bitcoin. This means that

vast amounts of computing power and energy are devoted simultaneously to solving the same problem, and the solutions to these problems offer no material benefit to humanity. The competitive aspect of mining is, however, important to ensure the integrity and security of Bitcoin transactions, as it makes it substantially harder for malevolent actors to tamper with the digital ledgers.

Researchers at the University of Cambridge estimated that, in 2016, the Bitcoin network accounted for about 0.4 percent of electricity consumption in the world. They noted that this amount of electricity could power all the tea kettles used to boil water in the United Kingdom for twenty-three years or could satisfy all the energy needs of their university for close to six hundred years. Arvind Narayanan, a computer science professor at Princeton University, estimated that in 2018 Bitcoin mining accounted for about 1 percent of world energy consumption.

Another researcher estimated that validating a *single* transaction on the Bitcoin network required power consumption equivalent to that of an average US household over about a month. According to this analysis, the Bitcoin network has a carbon footprint similar to that of New Zealand, an energy consumption total similar to that of Chile, and an electronic waste generation level comparable to that of Luxembourg. In fact, the electricity consumption of the Bitcoin network is estimated to be more than that of 150 countries in the world—only about forty countries have annual electricity consumption levels that exceed this network's annual electricity usage. The total cost of mining Bitcoin, adding up estimates of hardware and electricity costs, is $4 billion per year.

It gets worse. Many other cryptocurrencies use the same Proof of Work protocol pioneered by Bitcoin. These networks are smaller but still require mining activity. Moreover, many of the electricity estimates mentioned above apply only to running the ASICs, not to cooling them.

This has led to concentrations of mining pools in locations that have cheap electricity or cold temperatures. Preferred locations, such as Canada and Iceland, have both features. China and Russia are also believed to have large cryptocurrency farms, in part because of government encouragement and support, although such government support has waxed and waned over time in both countries.

Some industry groups have argued that the environmental costs of Bitcoin mining are overstated. A report by the group Coinshares, for instance, argues that mining hardware has become more efficient over time and that renewable energy sources account for most of the power consumption by the Bitcoin network. This argument ignores the opportunity costs of using even renewable energy for mining rather than other uses and, in any event, is already undercut by the rising computational complexity of mining operations on the network.

In short, while mining blocks on a blockchain under the Proof of Work protocol offers creative solutions to some real-world problems, it also uses a large amount of real-world resources. Mining requires ongoing purchases of hardware and an immense amount of energy consumption, both of which are harmful for the environment. Moreover, the mining process requires hardware to be running constantly on a full load, wearing out machines sooner than under more normal

operating conditions. Since ASICs are designed for just a single application, they also face rapid obsolescence and cannot be repurposed for other uses. The constant turnover of equipment thus creates a massive stockpile of obsolete parts. The advent of Bitcoin and the Proof of Work protocol it is built upon constitutes an environmental calamity.

**Alternatives to Proof of Work**

The cost and inefficiency of Proof of Work protocols have motivated the development of alternative consensus mechanisms that are needed to validate transactions that take place on a blockchain without a trusted third party involved. The most popular of these is Proof of Stake, which uses a different process to reach consensus. Since Proof of Stake does not need highly complex sums to be solved, the hardware and electricity costs of validating transactions are substantially lower. The second largest cryptocurrency by market capitalization, Ethereum, is in the process of shifting to this consensus protocol, which could happen in the next few months. Proof of Stake is not only environmentally less damaging but would also increase the network's ability to process a larger volume of transactions quickly and to increase the functionality of the blockchain.

While such alternative consensus protocols exist, Bitcoin miners may not be eager to make such a switch as it could devalue their investments in mining operations. Thus, their economic self-interest might end up exacerbating the environmental and social costs of mining operations.

**Broader economic impacts**

The broader economic impact of Bitcoin in regions that play host to cryptocurrency mining operations is probably minimal at best.

Cryptocurrency mining is a hardware-intensive operation with minimal human intervention that is limited to setting up the mining operations and monitoring them. In fact, other than physical maintenance of the network of computers involved in the mining, there might be little local labor involved—the monitoring of the network can be done from anywhere.

Given that all of the activity on the Bitcoin network is virtual, other than the mining operations which require hardware and attendant resources, there is little economic gain from these activities for the location in which mining operations are conducted. The tax consequences are also not obvious—even if the physical mining operations take place in New York State, they could be operated by firms that are headquartered in lower-tax jurisdictions and that end up having limited direct tax obligations to New York State. By contrast, any environmental damage caused by cryptocurrency mining will be mainly local (although of course there will be spillover effects at the national and global levels) and could take a long time to reverse.

In short, from a cost-benefit perspective, there is no good argument to be made for supporting the advent of extensive Bitcoin mining operations in New York State.