# SUSTAINABILITY OF THE CRYPTO-MONETARY BLOCKCHAIN : ESTIMATION OF ENERGY CONSUMPTION USING THE ECONOMIC METHOD

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## ABSTRACT

*In the booming field of blockchain technology, particularly in the context of cryptocurrencies, sustainability has become a major concern, mainly due to the significant energy consumption at the level of mining nodes. This article focuses on understanding the relationship between economic incentives in transactions, such as profitability, and the resulting energy expenditures, particularly in networks that use energy-intensive proof-of-work (PoW) mechanisms. Our study presents an accessible approach to estimate this consumption in crypto-monetary blockchain mining. Our model correlates energy consumption with economic variables such as cryptocurrency price, operational costs and mining hardware efficiency. By analyzing miners' income and the proportion of this income spent on electricity, we estimate overall energy consumption. This method allows for a more dynamic understanding of energy demand, reflecting real-time changes in market conditions. Our results suggest that the economic approach offers a viable alternative to traditional technical analyzes of energy consumption in blockchain networks. This methodology not only sheds light on the current environmental impact of cryptocurrencies, but also provides a framework for predicting future trends. The study aims to contribute to the ongoing discourse on blockchain sustainability, by offering insights that promote more energy-efficient blockchain technologies.*

**Key Words:** Cryptocurrency, Blockchain, Consumption, Sustainability, Energy.
**Jel Classification *:*** E22, E55, G11, G22

## INTRODUCTION

"Parallel finance has emerged as a concrete response to the significant transformations that have been reshaping the traditional banking profession since the 1980s. The initial shift followed the economic liberalization policies implemented initially in developed countries, and later in poorer and emerging nations. Governments and regulatory authorities decided to promote deregulation policies for financial actors, based on the belief in market self-regulation and the financial actors' capacity for self-control. This led to the development of disintermediated, opaque, and difficult-to-control markets, characterized by an almost complete absence of common prudential rules for all participants (Guttmann, & Plihon, D. (2010).).

The second upheaval relates to the modalities of banking intermediation. Indeed, under the dual pressure of shareholder return demands (owners of financial structures) and increasingly stringent prudential supervision standards, the financial system sought to expand and diversify its currency offerings (Pluchart, 2015). It developed an innovative form of intermediation, marked



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by intense and aggressive activity in the capital markets, an increasingly advanced automation of processes, and the dematerialization of liquidity."

All these changes have facilitated the emergence of a new paradigm based on reevaluating market actors, the concept of liquidity, and especially the pivotal notion of trust. The system as a whole is subtly and continuously undergoing profound changes, leading to an increasingly marked disengagement of humans as actors in favor of machines (Ali, & Barrdear, 2014). This robotization reduces the probability of failure due to the human factor while favoring the security and speed of operations. Thus, we find ourselves in an inclusive "bankless" finance, disintermediated and unsegmented. In this "high-frequency trading," liquidity with all the attributes of traditional currency is created by the algorithm; it is digital but also decentralized. Trust is placed not in humans through central banks, but in blockchain technology (Blundell-Wignall, 2014).

In this context, a central authority for issuing and regulating the money supply is nonexistent. Indeed, we are in an innovative finance realm at the cutting edge of technology, deeply rooted in the theory of free trade. However, its utilization raises several concerns, the foremost being ecological. Indeed, the consensus for validation through Proof of Work (POW) leads to high energy consumption. Our article aims to elucidate this issue through the so-called "economic calculation" model. Our main hypothesis is that the use of cryptocurrency enables inclusive and participatory finance in a context of optimal security, but its energy demand raises questions about its sustainability. For a relevant analysis of this question, we will first describe the public blockchain, then present the economic calculation formula, and finally conclude with a summary (Bollen, 2016).

## Description of the Public Blockchain

Digital currency is a virtual liquid asset that circulates on the internet, based on cryptographic technology for its issuance and the validation of its transactions. Popularized by Nakamoto in 2008, it liberates the financing-needy agent from traders, national, and supranational institutional intermediaries. It eliminates commissions and intermediation fees while optimizing peer-to-peer exchanges. In a dynamic of participatory management, it has become a product analogous to cash, in a secure environment devoid of a central authority (Brito & Castillo, 2014).

The advent of cryptocurrency is welcomed as a radical and predominantly positive evolution of money. It was the first prototype of a digital asset that is not backed by any other tangible good, has no intrinsic cost, and lacks centralized regulators and issuers. It is underpinned by the blockchain network which enables participatory control, thus avoiding any risk of redundancies and duplications in transactional activities.

The concept of decentralized digital currency and its dependencies, such as property registries, have been the subject of numerous studies for several decades. The anonymous protocols of electronic cryptocurrencies in the 1980s primarily stemmed from a cryptographic function known as Chaumian Blind (Chaum, 1981). This signature ensured a high degree of protection and anonymity for digital currency. However, this model could not become widespread due to its reliance on a centralized intermediary.

Dai's "b-money" cryptocurrency (1998) was the first experiment in monetary issuance through solving cryptographic primitives in a decentralized consensus context. However, the proposal was somewhat reticent about the process of applying the aforementioned consensus.



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For the first time, a decentralized currency was implemented by (Nakamoto, 2008) through the combination of primitives using asymmetric cryptography and a consensus algorithm. This process introduced the notion of "proof of work" to indelibly and unfalsifiably record the trace of possession. Today, cryptocurrency enjoys a certain maturity characterized by effective and generalized disintermediation of all operations, by permanent traceability, and finally by distributed consensus.

Trust is no longer entrusted to a moral institution but to all users who validate or invalidate transactions. Currently, there are about thirty cryptocurrencies in circulation. In terms of market dynamics, Bitcoin leads with a market capitalization of 19.4 billion dollars in April 2017, followed by Ethereum valued at 3.9 billion dollars, and Ripple at 1.2 billion dollars for the same period (Chabal, 2017). Some digital currencies prioritize total anonymity of transacting agents, where many others offer only pseudonymity. From a macroeconomic perspective, it is diluted into the M1 money supply.

Unlike central currency, cryptocurrency has a "customary" value, even though more and more economic operators accept it as a means of payment and debt settlement. In fact, operations are only possible between economic agents who accept it as an intermediary without any legal constraint. Compared to other assets whose quantity is regulated and value framed by central banks, cryptocurrency is stateless. Its value fluctuates solely due to supply and demand, which sometimes makes it a speculative currency of high volatility.

A cryptocurrency transaction between two agents involves an individual digital address of the type: 35sv1egv71wmzD1GePte0dtzVZdca5wK1e. This key is randomly generated when creating an account on a digital monetization platform. Anyone possessing it can send cryptocurrency to its owner. Most digital platforms utilize standard concepts of asymmetric cryptography, particularly the principles of private and public keys. A private key, known only to its owner, is used as a signature to validate transactions and as a decryption code for messages addressed to them. In contrast, a public key is an address that can be found in an "directory" of sorts and functions like a post office box. During a transaction, each injected token incorporates its origin to enable network nodes to trace ownership.

Therefore, considering all transactions are published in a distributed ledger, each node can track the movements of the encrypted tokens. The balance of a digital address is essentially a net accounting between the inputs and outputs of currency at that address. Once validated, the transaction leaves indelible marks, becomes irrevocable and irreversible due to a decentralized architecture. It is added to the block chain and will be permanently stored there. As we can see, an underlying contribution of cryptocurrency is blockchain technology as an instrument of distributed consensus and as a guarantor of the fiduciary aspect, which is indispensable and inseparable from the notion of money.

## Sustainability Calculation through the Economic Method

The energy consumption in blockchain technology, particularly for cryptocurrencies using a Proof of Work (PoW) validation consensus, is a complex subject that can be approached from various perspectives, including economic. This approach is the result of a collective evolution in the methods of economic and environmental analysis in the field of blockchain technologies and cryptocurrencies. Methods for estimating the energy consumption of blockchains, especially those using Proof of Work (PoW), have developed in tandem with the growing interest in the environmental impacts of such technologies. Various economists,



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researchers, and analysts in the fields of energy, blockchain, and finance have contributed to these analytical methods.

Organizations such as the University of Cambridge, with its "Cambridge Bitcoin Electricity Consumption Index" (CBECI), and other independent analysts in the cryptocurrency sector, have developed models to estimate the energy consumption of networks like Bitcoin. These models often consider economic variables such as the market price of cryptocurrencies, the cost of electricity, and the profitability of mining.

Therefore, the economic approach to calculating energy consumption in blockchains presented in this article is the result of a multidisciplinary collaboration and evolution, rather than the invention of a specific individual or group. To apply it, one must have a good understanding of the Consensus mechanism used. Indeed, this calculation technique is applicable only in a validation process using Proof of Work (PoW). This highly energy-intensive method requires a significant amount of computations (and therefore electricity) to validate transactions and create new blocks (Yahanpath, 2014).

### It is necessary to :

- Determine the average cost of electricity in the regions where the majority of miners are located.
- Analyze the profitability of mining, which depends on the price of the cryptocurrency, the cost of electricity, and the efficiency of the mining hardware.
- Estimate the total income of miners (the price of the cryptocurrency multiplied by the amount mined per day).
- Determine what proportion of these revenues is likely spent on electricity. This proportion can vary, but it is reasonable to estimate that a significant part of the income goes towards electricity costs.
- Use the estimated proportion and the cost of electricity to calculate the total energy consumption.
- For example, if miners spend 60% of their revenues on electricity, and the total revenues are 100 million FCFA per day with a cost of 80 FCFA per kWh, the energy consumption would be:

**Consumption = Revenues × Proportion / Cost per kWh = (100,000,000 x 60%) / 80**
= (100,000,000 × 0.600) / 80 = 750,000 kWh per day

### It should be noted that :

- Advances in the efficiency of mining equipment contribute to the reduction of energy consumption.
- The transition from Proof of Work (PoW) to Proof of Stake (PoS), which is less energy-intensive, significantly reduces energy consumption.
- The location of miners influences the cost of electricity and can affect the overall carbon footprint.
- Given that the cryptocurrency market situation is dynamic, it is important to periodically reassess energy consumption estimates as market conditions, technologies, and protocols change. This method provides an approximate estimate and heavily depends on the assumptions and available data. For a more accurate analysis, detailed data on mining operations is necessary, taking into account hidden costs, energy costs, and the technologies used.

## CONCLUSION

This study has successfully demonstrated the viability and importance of an economic approach in assessing the energy consumption of crypto-monetary blockchain systems, especially those relying on Proof of Work (PoW) mechanisms. Our research method, which intricately weaves together the economic variables of cryptocurrency mining, such as market



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prices, operational costs, and hardware efficiency, provides a comprehensive framework to evaluate the energy footprint of blockchain networks. This approach not only offers insights into current energy usage but also paves the way for predicting future consumption trends in response to evolving market dynamics.

The significance of our findings lies in the revelation that the energy consumption of blockchain networks is intrinsically linked to the economic incentives driving these systems. As cryptocurrency prices fluctuate and mining technologies advance, so too does the energy demand of these networks. This dynamic relationship highlights the need for a more adaptive and nuanced method of analysis, moving beyond traditional, static models of energy estimation.

Our study suggests that to achieve a sustainable balance in blockchain technology, a multifaceted approach is required. It is not enough to focus solely on technical solutions to reduce energy consumption ; there must also be an emphasis on aligning economic incentives with environmental goals. This includes encouraging the development and adoption of more energy-efficient consensus mechanisms, like Proof of Stake (PoS), and fostering a regulatory and economic environment that incentivizes sustainable practices in the cryptocurrency domain.

Furthermore, the implications of this research extend beyond the realm of blockchain and cryptocurrency. It presents a novel perspective on how economic analysis can be a crucial tool in understanding and managing the environmental impact of emerging technologies. As we stand at the cusp of widespread blockchain adoption, the lessons learned here could inform the sustainable development of various other technology sectors.

In light of these findings, it is imperative for stakeholders in the blockchain industry - developers, investors, and policymakers to take a proactive stance in integrating sustainability into the core of blockchain technology. This will not only help in reducing the environmental impact but also in ensuring the resilience and long-term success of these systems in an increasingly eco-conscious global economy.

In conclusion, our research contributes to a deeper understanding of blockchain sustainability, offering a novel methodology for energy consumption analysis. It calls for continued innovation and collaboration in the field, urging an alignment of economic and environmental objectives to forge a path toward a more sustainable future for blockchain technology.

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