Greengage

Can Blockchain Meet ESG Requirements?

A Review of Proof of Work and Proof of Stake

WHITE PAPER

Contents

Introduction

Over the years, Bitcoin[1] has garnered a particularly strong opposition from environmentally conscious individuals and groups for its power consumption. This is due to the enormous amount of computational power required to validate transactions and secure the network. As the network grows, so too does the computational power needed. This in turn increases the energy required to supply the additional computations. Currently, the Bitcoin blockchain has an estimated power demand of 14.77 gigawatts per hour at an average cost of $0.05 per kwh.[2] That is greater than Argentina's power consumption and at a cost of $6.47 billion per year. How reasonable though is this figure when compared to the energy consumption of other financial services rails? As shown in **Figure 1**, Bitcoin uses less than half the energy of either gold or the global banking system per year.[3] Obviously there are factors of scale to consider when comparing Bitcoin to such established mechanisms, but is the demonisation of Bitcoin wholly justified?

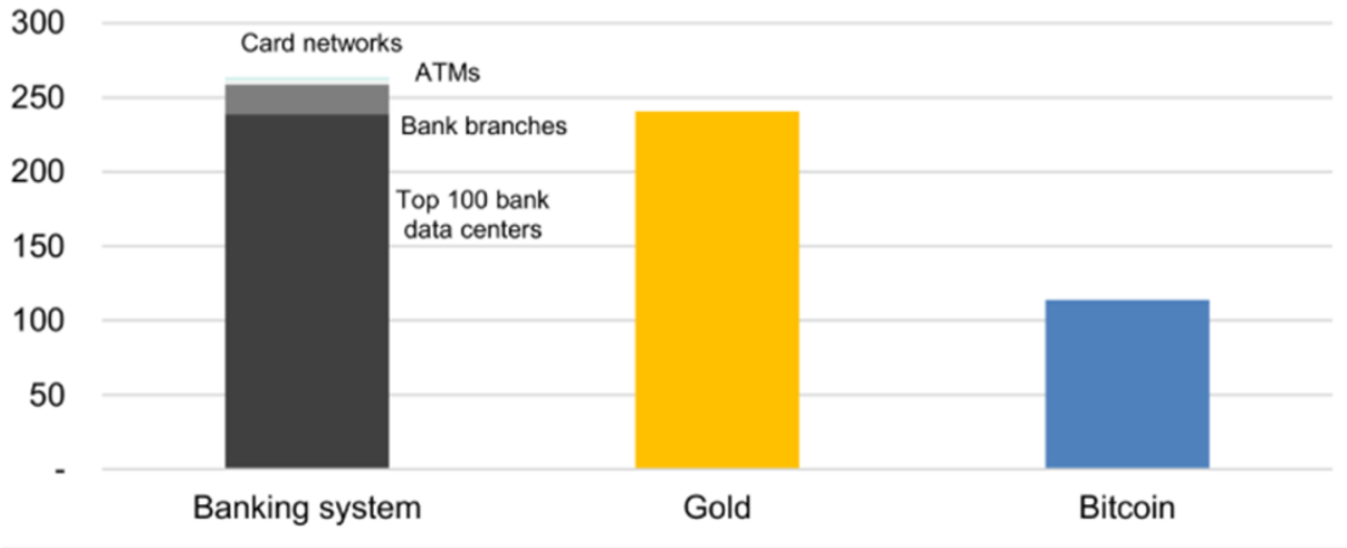
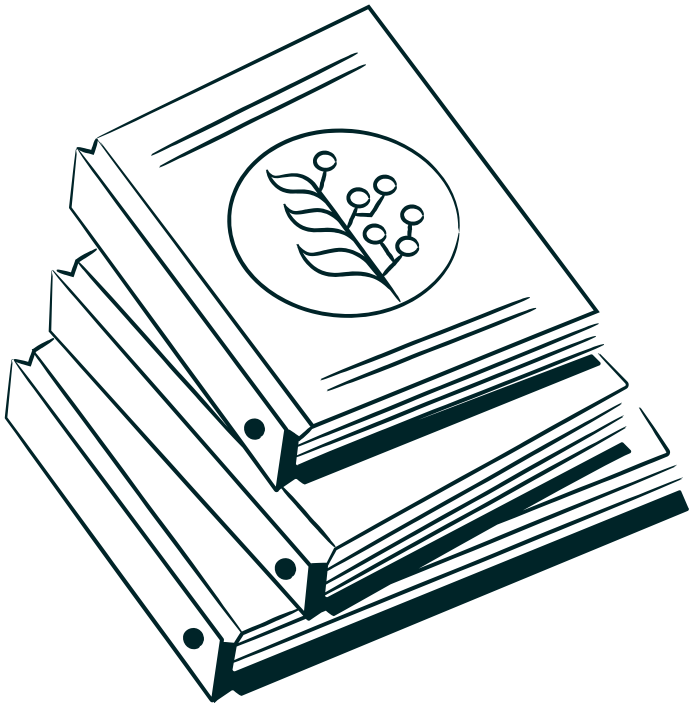


Figure 1: *Estimated annual energy consumption for Bitcoin, gold, and the global banking system* (source: Galaxy Digital)

1 Bitcoin (capitalised) refers to the network whereas bitcoin (uncapitalised) refers to the coin
2 Cambridge Bitcoin Electricity Consumption Index
3 On Bitcoin's Energy Consumption: A Quantitative Approach to a Subjective Question

However, these numbers do not paint a full picture. In fact, miners use several methods that reduce Bitcoin's carbon footprint and thus its impact on the environment, including the use of renewable energy to power the mining rigs and co-locating mining operations to take advantage of energy that would have otherwise been wasted. Furthermore, the stigma around Bitcoin's environmental impact has spread to other blockchains even though many are radically different by design. A popular variation of Bitcoin's proof of work consensus mechanism is proof of stake. This uses the locked funds of validators to ensure consensus instead of the investment of computational resources (see section **Proof of Stake** on p.10 for further details). Hence, the energy consumption of proof of stake blockchains is vastly reduced. Either one or a combination of these factors alongside the social good they could deliver would potentially align blockchains with the environmental, social and governance (ESG) factors, enabling them to qualify for ESG investing. We seek to explore this consideration in this paper.



ESG

ESG standards are factors linked to environmental, social, and corporate governance. They relate to how companies can take a more stakeholder-centric approach by upholding said standards in their operations. The environmental aspect is concerned with the preservation of our natural world. This is done by mitigating issues such as climate change, air pollution and deforestation. The social side values the consideration of humans and their interdependencies. As a result, it looks into customer success, inclusion, and community relations. Lastly, governance is linked with the logistics and defined processes for running a business. Therefore, it analyses the board of directors, venture partner compensation and hiring and onboarding best practices.[4] According to managing director, Remy Briand at MSCI, ESG investing can be defined as "the consideration of environmental, social and governance factors alongside financial factors in the investment decision-making process." There are various methods for ESG investing including top-down and bottom-up ESG integration as well as thematic investing.[5] ESG investing evolved from Sustainable and Responsible Investing (SRI) but is not considered as exclusive as its predecessor and so seems primed for wider adoption. Currently, ESG investing is continuing to grow as more countries pursue the Sustainable Development Goals (SDGs) and the general public becomes more socially and environmentally conscious. Even during 2020 in the midst of the pandemic, ESG funds gained a net $5.1 billion in new investment from the previous year, suggesting that ESG investing is here to stay.[6]

4 What is Environmental, Social and Corporate Governance (ESG)?
5 ESG 101: What is Environmental, Social and Governance?
6 The History of ESG Investing

Proof of Work

Mining

Proof of Work ("PoW") is a popular consensus mechanism utilised by Bitcoin and many other blockchains (or "cryptocurrencies" in more common parlance). The purpose of PoW, like other consensus mechanisms, is to ensure that participants act in accordance with the best interests of the network despite the lack of trust between them. The participants who validate transactions and add them to the network are called miners. They add validated transactions to the blockchain by solving a cryptographic puzzle that involves finding the random number (nonce) that produces a string with a certain number of zeroes at the start (target hash). This is done by combining the nonce with the hash of the previous block and a new set of transactions using a hash function. Only a brute force approach can be used to find the correct nonce and roughly 10^21 calculations are needed in the case of Bitcoin. Thus, unless you have the infamous HAL 9000 to hand, mining is a costly process, both in terms of electricity and computational power. The first miner to find the solution gets to add the next block and receives all the associated transaction fees as well as newly minted native cryptocurrency for their troubles.

Through all this literal "work", the security of the network is maintained as it deters bad actors from falsifying transactions. Verifying the solution is very simple and requires only one calculation. Therefore, bad actors cannot avoid the work required to add a block to the network and if their block contains false transactions, it will be dismissed quickly by the other miners. This is because the bad actor's block will be seen as having an invalid solution or incongruent with the chain of previous blocks. The difficulty is automatically adjusted by changing the number of zeroes the string needs to have at the start (more zeroes, higher difficulty) so that the average time until someone solves the puzzle remains stable (approximately 10 minutes for Bitcoin).[7] Consequently, it is future proofed against advances in classical computational might and even quantum resistant.[8] Overall, when there are enough miners, this resource intensive mechanism leads to a high level of security with Bitcoin never knowingly having been hacked to date.

7 Proof of Work – What It Is and How Does It Work?
8 Here's Why Quantum Computing Will Not Break Cryptocurrencies

Renewable Energy

Due to the energy demands of proof of work, many Bitcoin miners have incorporated the use of renewable energy to reduce their carbon footprint. Consequently, bitcoin mined using renewable energy is colloquially known as "green bitcoin". An example of a company taking a big step in this direction is Lancium. The Houston-based tech company raised $150 million to utilise over 2 gigawatts of renewable energy for its mining operations across Texas. That is the output of roughly 4 coal-fired power plants and nearly double the amount of power required to send a DeLorean 30 years back in time. The location is ideal for Lancium as it has some of the highest wind speeds and the cheapest utility-scale solar power in the US.[9]

Another mining company vying to become a dominant player in this space is Bitdeer Group. Based in Singapore, Bitdeer Group is one of the world's leading digital asset mining service providers and was founded by Bitmain co-founder, Jihan Wu. Their success can be attributed to their customer-centric approach which states that it is the customer's needs that fuels innovation. This mentality aligns well with ESG and led to the introduction of their new business line, Mining Datacenter, which is dedicated to the use of renewable energy for mining. Mining Datacenter operates in several countries including the US and Norway. In the US, one of the mining facilities is entirely powered by hydroelectricity while the other two sites use a mix of solar, wind, nuclear and hydroelectric energy alongside traditional energy sources. In Norway, 95% of the energy used by two facilities is hydroelectric. Globally, Mining Datacenter is expected to near 3 gigawatts in capacity by 2023.[10] Bitdeer Group's success has led to a recent announcement of their aims to go public through a SPAC merger with Blue Safari Group Acquisition Corp. The merger values Bitdeer Group at approximately $4 billion which in terms of size, puts it in the upper echelon of SPACs.[11]

The pursuit of green bitcoin has led to the majority of mining power (57.7%) being derived from renewable energy.[12] However, the green revolution is not exclusive to Bitcoin. Cambridge's 3rd Global Cryptoasset Benchmarking Study has found that 76% of miners across the multitude of cryptocurrencies use renewable energy. In total, over 39% of the power used by proof of work cryptocurrencies such as Bitcoin and Ethereum was supplied by renewable energy sources. Of these sources, hydroelectric power has been adopted by nearly 62% of miners, making it the most popular renewable source. Moreover, as seen in **Figure 2** on p.7, hydroelectric power is the most common source of energy even when including fossil fuels, beating other sources by a wide margin in nearly all regions.[13] By now, the image of cryptocurrency as the digital equivalent of a coal roller may not be as straightforward as some would suggest.

9 This Houston tech company wants to build renewable energy-run bitcoin mines across Texas
10 Bitdeer Group Introduces Industry-Leading Mining Datacenter
11 Bitdeer Group's Customer Obsession Approach Brings It to the World Top Player
12 Calls For Tesla To Resume Bitcoin Payments As Mining Reaches 57% Renewable Energy
13 3rd Global Cryptoasset Benchmarking Study

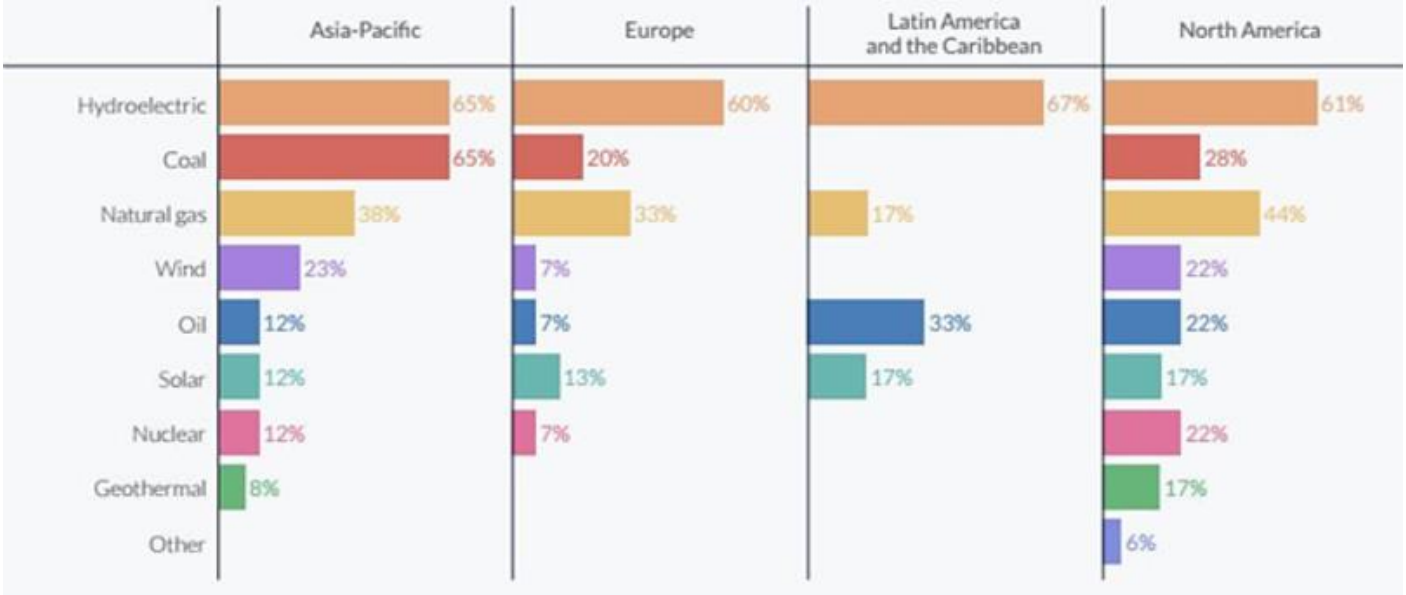
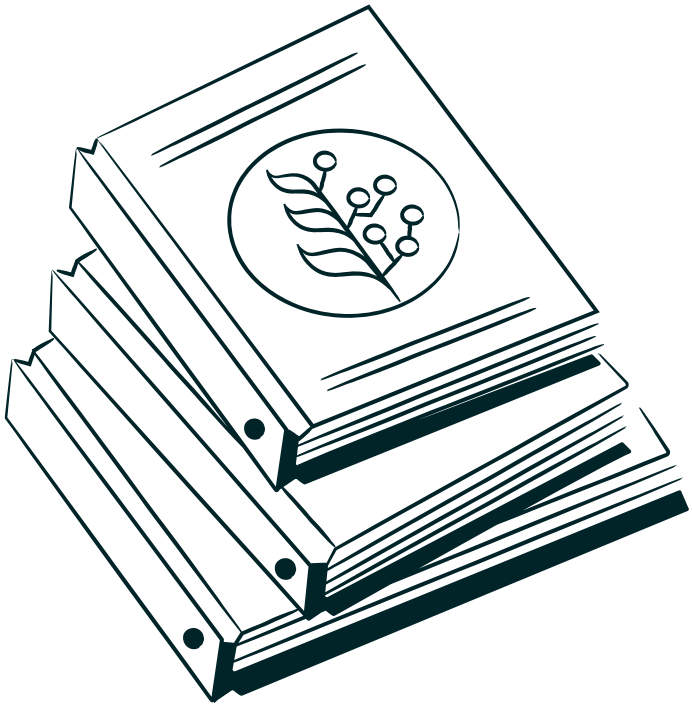


Figure 2: *Energy sources per region for mining*
(source: University of Cambridge)



Co-Location

Miners can also mitigate the environmental impact of proof of work blockchains by co-locating. This involves moving the mining site to a location where the energy being produced would have otherwise gone unused, either due to capacity or profitability/maintenance issues. The latter has led to cases where a co-located mining operation prevented a renewable energy site from shutting down. With government subsidies for renewables being cut globally,[14] mining-dependent renewable energy production may become more common going forward. For capacity issues on the other hand, the previously mentioned company, Lancium, is a good example. When there is excess renewable energy to the point where supply exceeds demand, Lancium's mining sites absorb the surplus at a cost, monetising the energy that would have been wasted. On the other hand, the sites power down during periods of high demand to avoid scarcity. As a result, they ameliorate the volatility of renewable energy for the grid. Another mining company in Texas called TeraWulf has entered a joint venture to produce zero-carbon bitcoin through co-location. Their joint venture with Talen Energy is named Nautilus Cryptomine and involves siphoning off the excess power of a nuclear power plant during lulls in demand to produce bitcoin with a negligible carbon footprint. Part of Talen Energy's Force for Good ESG strategy, the project will have a capacity of roughly 300 megawatts at some of the cheapest rates in the US.[15]

Co-location mining even has the ability to offset the carbon emissions of fossil fuels. Miners are now using flare natural gas to power their mining operations. This gas is a byproduct of oil and natural gas production and occurs when producers do not have the capacity to process the excess. Consequently, the flare gas is instead burned. As you would expect, this releases dangerous greenhouse gases such as methane direclty into the atmosphere. In 2019, the amount of natural gas flared globally had the same carbon footprint as Italy. A common reason for the lack of capacity is the processing no longer being econmically viable due to low prices. This is where mining comes in. The excess natural gas can be sold to miners to produce bitcoin, avoiding waste and offseting carbon dioxide emissions in the process. EZ Blockchain are a mining company using this method to mine bitcoin in six locations across New Mexico, Utah and Canada. Furthermore, oil and gas companies in Russia are seeking regulatory approval to use this method following a test case by a local mining company where 1.8 bitcoin was mined using flare gas.[16] Additional co-location sites could soon follow across the globe as the use of carbon credits becomes more prevalent. The prospect is also economically tantalising to miners since costs could fall below $0.018 per kwh, over three times cheaper than the average $0.05 per kwh.[17]

14 Does renewable energy have a subsidy-free future?
15 Talen Energy Corporation Announces Zero-Carbon Bitcoin Mining Joint Venture with TeraWulf Inc.
16 Russian Oil Companies Want to Mine Crypto on Flare Gas: Report
17 Flared natural gas powers Bitcoin mining

Proof of Stake

Staking

Proof of Stake ("PoS") is an alternative to proof of work and also the second most common consensus algorithm for blockchains. However, the two are fundamentally distinct as shown in **Figure 3** below. Firstly, proof of stake does not feature any cryptographic puzzle. This means there is no need for enormous computational power and thus miners. Instead, proof of stake uses validators to create and verify blocks on the blockchain. In addition, validators act as the nodes of the network and hence store a copy of the blockchain which is kept updated as new blocks are added. To become a validator, one needs to stake a certain amount of the native cryptocurrency of the network. This involves locking that cryptocurrency in a smart contract for as long as you are a validator. When a new block needs to be added to the blockchain, an algorithm will randomly pick a validator to propose which block of transactions should be added. Then other validators "attest" that proposed block which means they verify that the proposed block contains no dishonest/malicious transactions. If a block receives enough attestations, it is added to the blockchain. Commonly, the probability to be chosen to propose a block is weighted by the amount the validator has staked.[18] For PoS blockchains with a limit on the amount staked per validator, the probability increases the more validators a user is running.

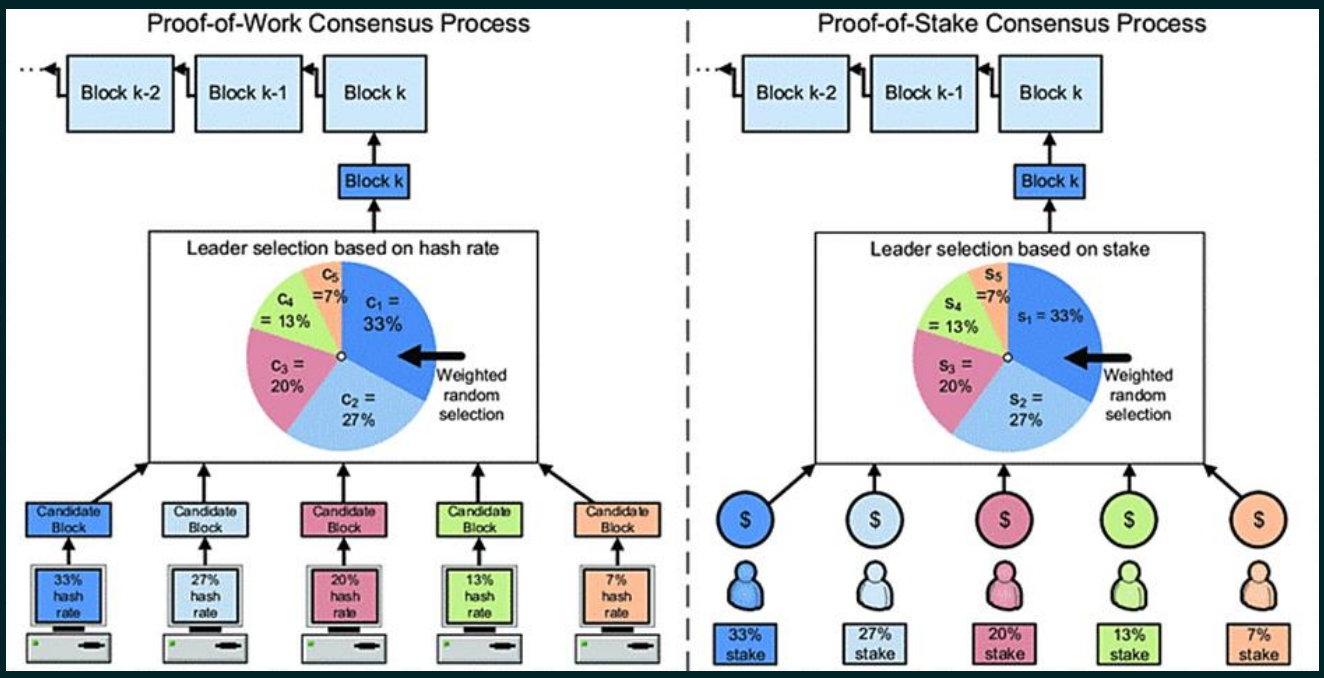


Figure 3: *Proof of Work and Proof of Stake consensus process*
(source: Nguyen et al., 2019)

18 Proof-of-Stake Consensus Mechanisms for Future Blockchain Networks: Fundamentals, Applications and Opportunities

Both the randomly selected proposer and the attestors receive a reward for their contribution to the network in the form of the transaction fees of the added block. On the other hand, if the proposer or the attestors fail to perform their duties to the network, they will be penalised. The usual reason for this occurring is if the validators are offline when it is either their turn to propose or attest. Typically, this only incurs a minor penalty so remaining online most of the time will lead to a net gain in income. Conversely, much stricter fines known as slashing penalties are delivered to those proposing or attesting malicious blocks. As those actions are considered as attacks on the network, a large percentage or even the entire amount of staked crypto might be slashed.[19] Therefore, proof of stake achieves consensus through the proverbial carrot and stick that has gripped the minds of mules and men for thousands of years.

Energy Consumption

Proof of stake does not require the solving of a complex cryptographic puzzle to maintain consensus. The hardware specifications needed to run a validator node are well within the range of a standard PC for even the larger blockchains. Having enough storage to store and sync with the growing blockchain is the main concern though a one terabyte hard drive/SSD is more than enough for even the biggest PoS blockchain, Ethereum. Thus, neither the large expensive mining hardware nor the massive amounts of energy are necessary. The only substantial energy requirement is that the validators must stay online most of, if not all of the time. Nonetheless, this is miniscule compared to mining. In fact, a UCL discussion paper estimates proof of stake blockchains/distributed ledger technologies use at least a thousand times less energy than Bitcoin. Besides Ethereum 2.0, other prominent examples include Cardano, Polkadot and Algorand.[20] For Ethereum, its transition to proof of stake through Ethereum 2.0 is predicted to reduce its energy demands by 99.95%.[21]

19 What Is Proof of Stake?
20 Energy Footprint of Blockchain Consensus Mechanisms Beyond Proof-of-Work
21 Ethereum's energy usage will soon decrease by ~99.95%

Social Contribution

One often neglected aspect in the debate around whether blockchain should be included in ESG is its social impact. Through decentralised, disintermediated and permissionless setups, blockchain can aid vulnerable communities by alleviating many of the issues they face around transparency and access, irrespective of the consensus mechanism used. One example would be boosting financial inclusion. With 31% of adults worldwide (1.7 billion people) being unbanked,[22] the lack of access to financial services is a huge problem. There are four ways in which blockchain can help, namely: 1) cheap, efficient payment services, 2) low barrier saving, 3) easily available credit with flexible collateral and 4) accessible insurance. Disintermediation though the use of smart contracts simplifies activities such as claims processing and loan repayment while permission-lessness greatly improves ease of access. These applications are no longer confined to the pages of the whitepapers for "the TRUE Ethereum-killer" or "the NEXT Bitcoin" either. There are already real-world projects like the payment service Leaf and the saving app Xcapit being used by thousands across the world.[23] As adoption of such platforms increase, the greater the number of people who can achieve financial stability and freedom.

Another issue blockchain technology can diminish is food waste. A recent report by the WWF and Tesco states that approximately 40% of all food produced globally is wasted. This amounts to 2.5 billion tons[24] or five Burj Khalifas worth of food (for those who like to use buildings as a unit of measurement). There are a variety of reasons for why food goes uneaten including bad weather, overproduction, and supply chain problems.[25] Although blockchain is not a panacea, it can address several of these either directly or indirectly. Using blockchain technology with Internet-of-Things (IoT) devices enables the cheap and secure monitoring of all stages of the supply chain. This allows for the tracking of weather, contamination and overproduction among other factors which results in the supply chain being more efficient. Consequently, widespread utilisation of these tools could cut food waste in half by 2030. Since the current amount wasted would be able to feed the 815 million hungry people in the world many times over, blockchain and IoT enhanced supply chains could be a big step towards ending world hunger.[26] If that is not reason enough, there is also the fact that if it was a country, food waste would be the third biggest greenhouse gas emitter.[27]

22 The Global Findex Database 2017
23 Working Toward Financial Inclusion With Blockchain
24 Driven to Waste: Global Food Loss on Farms
25 The Problem of Food Waste
26 Three ways technology can help reduce food waste
27 CO2 Emissions by Country

Conclusion

There are many ways in which blockchain can qualify to be a part of ESG investing. This includes both proof of work and proof of stake blockchains. The direct approach for the former is to use renewable energy for mining operations. This has already been incorporated by most miners and adoption is likely to continue its upwards trend. The other method miners use is to co-locate with power generation sites where excess energy is wasted. Here, the mining operation aids the power grid by acting like a battery to absorb the excess and by providing an additional source of revenue. For non-renewable energy sites, co-location mining can also offset their carbon emissions as seen with flare gas mining.

Conversely, proof of stake blockchains tackle the amount of energy consumed directly as they avoid the use of large amounts of computational power to achieve consensus. All in all, blockchain is substantially greener than it is portrayed. Right now, ESG investing could include proof of work blockchains but would likely need to be limited to mining companies that primarily use either renewables, co-location, or both for a majority of the crypto they mine. On the other hand, proof of stake blockchains should already be integrated into ESG investing on account of their efficiency. Nevertheless, adding blockchain's ability to uplift society by e.g., increasing financial inclusion and reducing food waste should enable the technology to meet the criteria for ESG investing regardless of consensus mechanism. Whether it is proof of work or proof of stake being used, blockchains are in reality not as odious as their critics would suggest – in fact, far from it.

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