GREENING BITCOIN WITH INCENTIVE OFFSETS

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Executive summary

We propose a way to invest in bitcoin without contributing, even slightly, to unsustainable bitcoin mining. If one co-invests in sustainable mining operations in proportion to the size and duration of one's bitcoin holdings, one's bitcoin and green mining investments together will produce no net incentive to mine bitcoin in a carbon-intensive way. We estimate that, given current price, hashrate, issuance, and transaction fee levels, a quarterly allocation of approximately .5% of one's bitcoin investment into green mining will suffice. Unlike other proposals to green bitcoin, ours preserves bitcoin's fungibility and costs nothing. In fact, it provides a positive return.

We begin with two assumptions. First, bitcoin is an attractive investment, environmental impact aside; second, carbon-intensive bitcoin mining is to be minimized. Readers who think bitcoin has no value whatsoever, or who think any focus on carbon reduction is a mere distraction, may look elsewhere for guidance. For readers who do share our assumptions, we will:

1. explain how owning bitcoin incentivizes mining, including carbon-intensive mining;
2. show how green mining, given bitcoin's issuance structure, provides a disincentive to other miners, including carbon-intensive miners;
3. show how to balance these two incentives;
4. calculate the cost to balance a given bitcoin investment;
5. discuss possible financial products and services to achieve this balance for investors;
6. compare our proposal, favorably, to other options.

Bitcoin investment incentivizes mining

All mining revenue comes in the form of block rewards and fees. Currently, 328,500 bitcoin in block rewards are claimed by miners annually, while roughly 18,000 bitcoin are collected in transaction fees. The value of these rewards and fees, which are denominated in bitcoin, depends on bitcoin's price, for which investors—who hold bitcoin and thus suppress available supply—are collectively responsible. What can appear to be inert (merely holding)

is in fact an active ingredient in bitcoin price discovery and mining profitability. Thus, mining's externalities are the indirect result of bitcoin ownership.

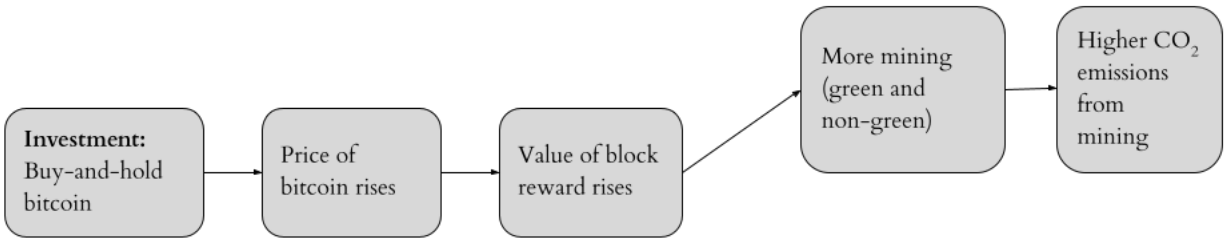

Figure 1: Price Incentive

Green mining disincentivizes mining

Investors can counterbalance this incentive to mine by mining themselves, sustainably and in the right proportion to their bitcoin investment.[1] Here's how. Mining is a zero-sum game. More computing power does not produce more bitcoin. Rather, the protocol fixes bitcoin's issuance per block—currently 6.25 bitcoin—and adjusts the difficulty of mining to keep blocks coming, on average, every 10 minutes. The result is that over time, the expected reward for a given amount of computing power is inversely proportional to the total amount of computing power in the network: the greater the total hashrate of the network, the lower the payout, in bitcoin, at any given hashrate.

[1] "Sustainable mining" or "green mining" here is a variable: our proposal is compatible with various definitions. For instance, some will think mining with flared gas—which transforms methane into a far less potent greenhouse gas, carbon dioxide—is a green form of mining. Others will exclude it. Nuclear energy, we imagine, will spark a similar divide. But by "green" we mean whatever you, the reader, take to be green. Investors with specific ESG mandates may plug their own institution's definition of "E" into our proposal. We will not broach the "S" and "G" components of those mandates here.

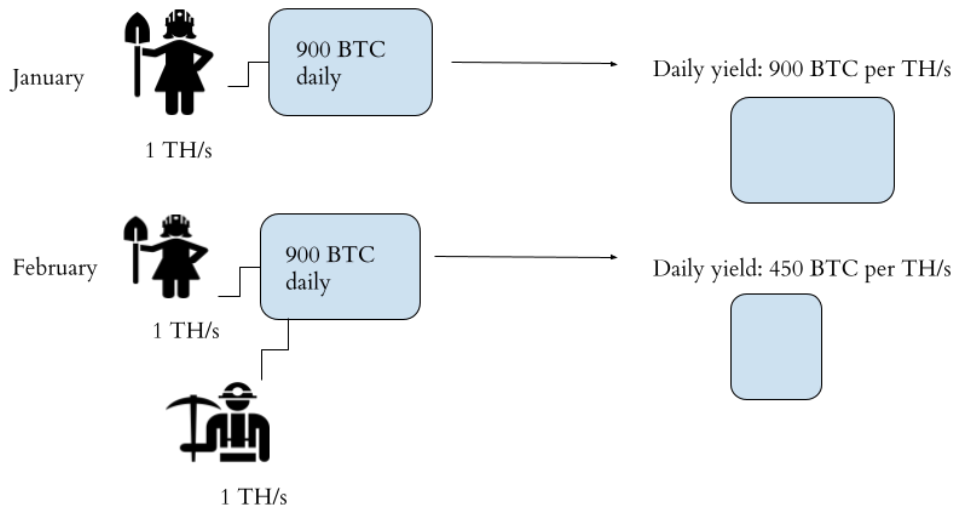

Figure 2: Mining Rewards

New green mining means faster block discovery, which makes mining difficulty go up, which drives up the energy and hardware costs required to mine a given amount of bitcoin, lowering the incentive to mine, and thus lowering emissions from mining.

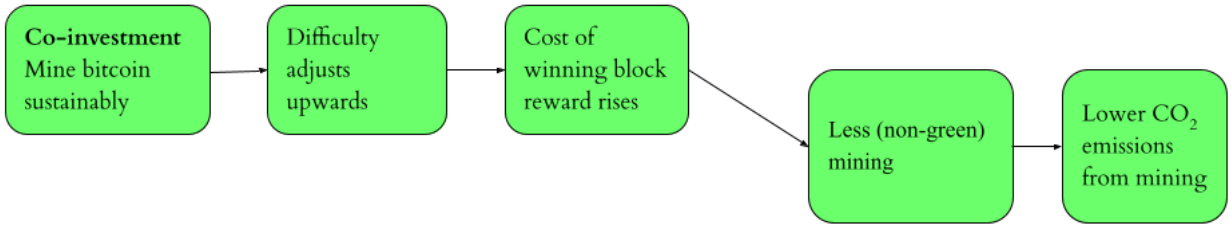

Figure 3: Difficulty Disincentive

There is an equilibrium where the incentive to mine created by our investment in bitcoin is precisely balanced by the disincentive to mine created by our own mining. This is the point at which what we give to the carbon-intensive miner with one hand (increased value of block reward through holding bitcoin) we take away with the other (increased costs to win a block reward through green mining). Our two investments together have made no difference to miners' profitability even though we are now in possession of bitcoin.

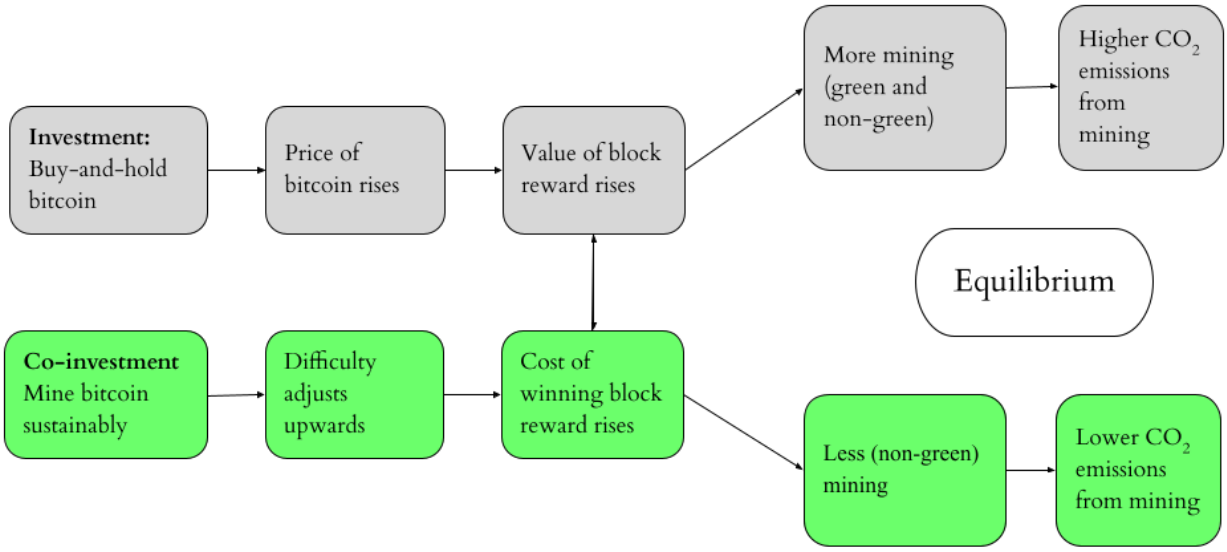

Figure 4: Price Incentive + Difficulty Disincentive

How to find the point of incentive equilibrium

The equilibrium is where one's proportion of bitcoin's effective market cap equals one's proportion of hashrate. If you own x% of all bitcoin and also do x% of all mining of bitcoin, then regardless of what x is, the expected value of mining at any given hashrate will be just the same as if you neither owned any bitcoin, nor mined yourself. You will have, in effect, mined all of the incentive to mine that was created by your investment.

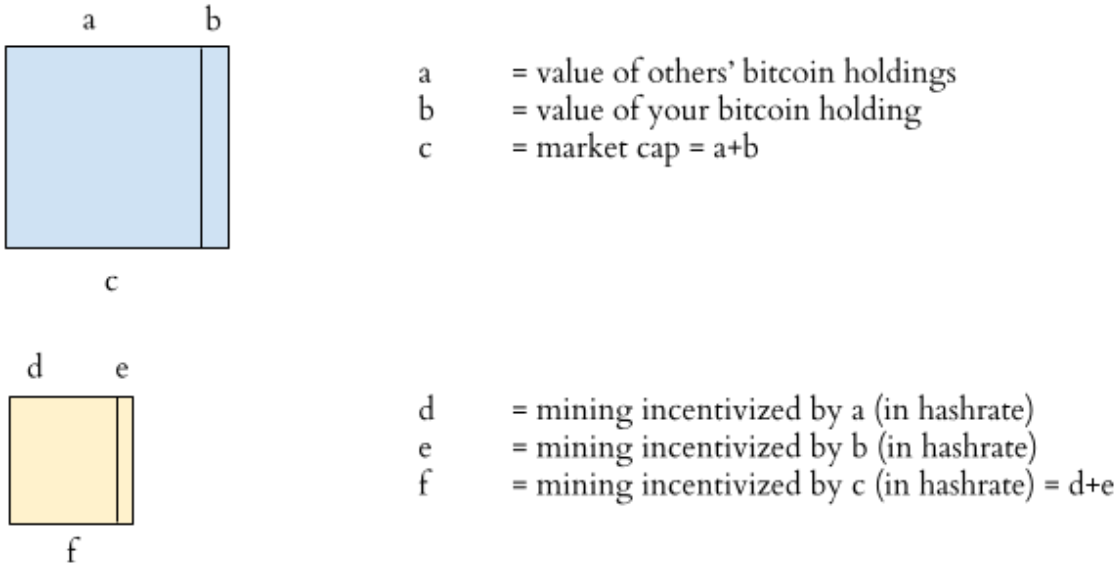

Figure 5: Proportion of market cap = proportion of hashrate

In Figure 5, provided b and e scale together, d remains constant. Miners do not "see" your investment, because although price is higher than it otherwise would be, difficulty is also higher in equal measure.

How much to invest in green mining

We now calculate the required co-investment in green mining. Begin with the source of all price incentives: the effective market cap of bitcoin. The total amount of bitcoin that has not been lost is approximately 15 million. At $34,000 per bitcoin that yields an effective market cap of $510 billion. Next consider the total incentive to miners, on a quarterly basis. Their expected quarterly mining revenue is 82,125 bitcoin in block rewards and 4,500 bitcoin in fees, or $2.95 billion. So total quarterly mining revenues are about .575% of effective market cap. Likewise, each individual investor is also providing an incentive to miners, quarterly, worth .575% of their own holdings. A $100,000 investment across 90 days thus incentivizes $575 worth of mining rewards.

If green mining had an expected net return of zero, we would recommend a quarterly co-investment in green mining worth .575% of one's bitcoin allocation. If green mining were profitable, as it presently is, then the investment required in green mining may be substantially less, perhaps .5%. At the end of each quarter, one could fold the returns from mining back into more mining and adjust as needed, since market cap, hashrate, the profitability of green mining, and one's own investment size may all have changed in the meantime. The co-investment suggested here is modest and compares to what investors already pay when securing their bitcoin (50 basis points is a standard OTC fee, for example).

How to invest in green mining

Two questions remain: how, exactly, should investors allocate towards green mining, and how does our proposal stack up against green alternatives?

What's needed here is a financial product—call it a Green Co-investment Instrument (GCI)—that takes as inputs: effective market cap, hashrate, fees, block rewards, the profitability of green mining, and the size of an investor's bitcoin holdings. As these variables change, the GCI must change with them, to calibrate price incentive with difficulty disincentive, keeping them in balance. We imagine, then, a quarterly subscription service tied to an investor's bitcoin allocation. The service computes the other inputs and charges a fee, which is then allocated toward green bitcoin mining. Proceeds from that mining are then distributed back to investors either as a dividend or toward their future GCI

subscription fees. Investors would subscribe to a GCI service only as long as they held bitcoin.

There is room here for variety and competition. Some GCI providers will cater to accredited investors or institutions. Others will go bitcoin-native, serving pseudonymous accounts with subscription intervals marked in blocks rather than quarters and fees denominated in bitcoin. Some investors will prefer to self-custody their bitcoin and want a "mining-only" subscription. Others will subscribe to an integrated product that custodies bitcoin and automates regular GCI adjustments that minimize green mining as a percentage of total investment given transaction costs and tax considerations.

There are, in short, a variety of ways to implement our proposal. All will green bitcoin, all will strengthen the security of the bitcoin network, and in different ways, all will serve the disparate needs of bitcoin holders.

Why alternatives fall short

Alternative proposals for greening bitcoin include:

1. Carbon offsets
2. Green coins—colored UTXOs from blocks discovered by mining pools with a known and sufficiently favorable energy mix
3. Hybrid products that integrate (i) and (ii) as a wrapped token on another blockchain
4. Moving bitcoin away from proof of work altogether

Our proposal differs from mere carbon offsetting. We instead suggest an *incentive* offset so that one's bitcoin holdings do not lead to any new carbon-intensive mining which later requires atonement. Unlike carbon offsets, our proposal is also likely net profitable, and thus relies on neither charity nor coercion. Our proposal, finally, does not require knowing the total energy mix of bitcoin mining: how much hashrate derives from burning coal or natural gas, for example. We recommend that bitcoin investors literally mine the entirety of what they incentivize, so an investor only needs to know that the hashrate they are purchasing is green, by their own definition of "green." The broader mix is irrelevant.

Colored UTXOs are a bad idea on ethical, economic, and engineering grounds. *Bad ethics*: these schemes presume that having acquired some green UTXOs of known provenance, one's moral work is done. But the procedure doesn't take into account the temporal dimension of the incentive to mine created by holding bitcoin; the incentivization of unsustainable mining is not just a matter of how much bitcoin one has but for how long.

Our proposal, by contrast, makes ongoing co-investments in green mining to match bitcoin holdings so long as those holdings last. *Bad economics*: colored UTXOs do violence to bitcoin's fungibility, which threatens bitcoin's ability to serve as a genuine monetary network. If your investment thesis is that bitcoin is or could become a global monetary network or native currency for the internet, colored coins are not for you. *Bad engineering*: there is no fair and technically sound way to track an "individual bitcoin" or an individual UTXO across a tree of transactions. The input UTXOs to a transaction are *spent* and its outputs are *new* UTXOs with no certain link to particular inputs; where there are multiple inputs, then, a given colored input can't be linked to a given output.[2]

Lastly, abandoning proof of work is a non-starter. The assurances provided by bitcoin's security model are battle-hardened and a key element of bitcoin's attraction. Hybrid products fail for similar reasons: a wrapped token, created by trusted custodians, with additional attack vectors, and hosted on another blockchain altogether cannot make good on the promises that have attracted capital to bitcoin in the first place. Wise investors want bitcoin, not some simulacrum.

Conclusion

Bitcoin mining's environmental reputation is less than stellar. ESG mandates currently prevent some institutions from embracing bitcoin, and uncertainty in the matter blocks others—individuals and institutions alike—from entry. Instead of changing bitcoin itself—undermining fungibility, abandoning proof of work, or hosting wrapped bitcoin on a competing blockchain—bitcoin's own inner workings can be used to engineer a financial instrument that eliminates its negative environmental externalities. Bitcoin's difficulty adjustment and fixed issuance allow investors to precisely balance their price-based incentive to mine with an equal and opposite difficulty-based disincentive, simply by mining sustainably themselves. Broad adoption of this practice would further strengthen bitcoin's settlement and security assurances, improve not only bitcoin's environmental reputation but its actual environmental record, and unlock capital currently bound by either ESG mandates or individual conscience. In sum, we see no real tension, or tradeoff, between an enthusiasm for bitcoin and a thoroughgoing commitment to a low-carbon future. Rather, we see the possibility for a win for bitcoin, and for the world.

References

Warmke, Craig (2021). "Electronic Coins". Draft available online: https://www.resistance.money/EC.pdf

[2] Warmke (2021).