

P A N T E R A

EXCERPTS FROM OUR BLOCKCHAIN LETTERS

Institutional Adoption

December 7, 2021

IT'S A PONZI SCHEME

I've heard that line for eight years.

Regulators are talking about bubbles and manipulation constantly.

The markets have it right – there is a massive Ponzi scheme going on. Let's investigate.

MANIPULATED MARKET

"The Commission concludes the requirements of Exchange Act Section . . . be 'designed to prevent . . . manipulative acts and practices' and 'to protect investors and the public interest.'

"A pyramid scheme that is heavily rigged and from which the only way to profit is to sell to a 'greater fool' who comes later at a higher price.

"The Commission has raised in previous orders, which have included. . . persons with a dominant position in bitcoin . . . trading based on material, non-public information"

– SEC Order Disapproving a Proposed Rule Change to List and Trade Shares of the VanEck Bitcoin Trust, November 12, 2021

The bitcoin market is way too big to be manipulated. Bitcoin trades on hundreds of exchanges in dozens of countries. Bitcoin's daily volume is 1,000x as much as GameStop, which trades on just one market in just one country.

[SEC Commissioner Hester Peirce makes a very cogent argument that the bitcoin market is, in fact, adequately self-regulated [here](#).]

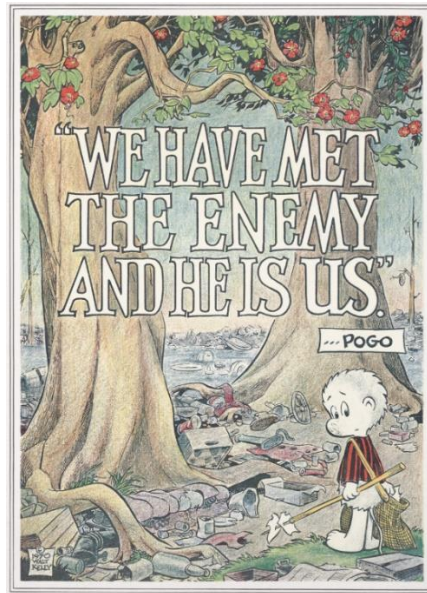
BUBBLE

"Bitcoin (and most other Crypto-assets) as an investment asset is difficult to rationalize, which would suggest that we see a buildup of a historic bubble.

"However, legislators have encouraged fresh speculative inflows into crypto-assets through laws such as the German Fondstandortgesetz risk to fuel the bubble and increase the eventual societal problem."

– Ulrich Bindseil, Director General of the ECB's Directorate General Market Operations, November 19, 2021

All this extreme positioning on bitcoin doesn't make any sense. How can you have a bubble almost nobody owns? Something like 90% of institutional investors have no exposure to bitcoin or other blockchain tokens. It's definitely not a bubble.



"To know thyself is the beginning of wisdom."

– Socrates

BOND BUBBLE

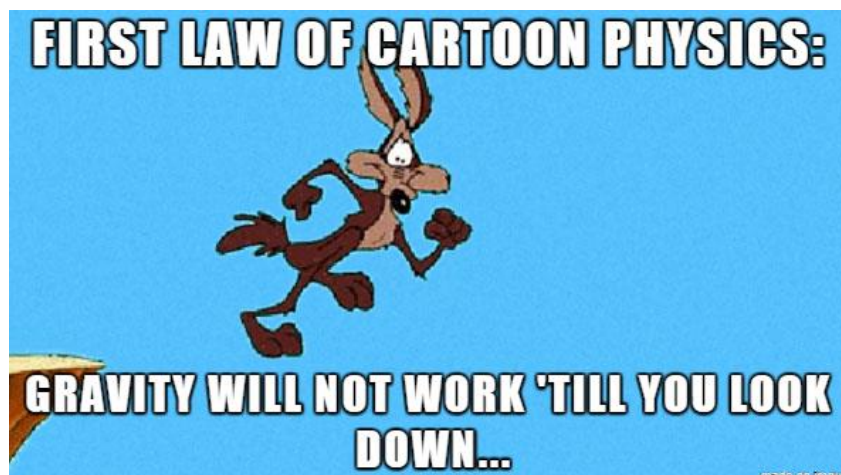
Governments should stop obsessing about bitcoin and look inward. The biggest Ponzi scheme in history is the U.S. government and mortgage bond market – 33 trillion-with-a-T dollars – all being driven by one non-economic actor with a dominant position who is trading based on material, non-public information.

All this handwringing from the Fed about "the Taper" in future years. What?!?! The Fed's strategy should be "Cold Turkey" – right now.

"Basta!"

Somebody should file a Federal Whistleblower Protection Act claim against the Fed under the statute's clause against "gross waste of funds". It's clearly a huge waste of funds to print \$50,000 per family in America to push up the price of the mortgage bond REITs that Fed presidents own and the assets of other wealthy people while destroying the purchasing power of the average American, making homes unaffordable for the 35% who don't own a home, and saddling our children with more debt that it took to win World War II.

Bonds will experience a Wyle E. Coyote moment. Not sure if it's next week or down the line. After the mid-terms? But it is certain.



HEDGING INSTITUTIONAL BOND HOLDINGS WITH BITCOIN

Someday financial gravity will resume functioning.

If you're an institutional investor with any bonds, but especially if you're more like the classic 60/40 stock/bond portfolio, you might want to hedge the bond bubble with bitcoin/crypto assets.

ASYMMETRIC TRADES

I've spent my career looking for asymmetric trades – trades where the upside is many times the downside. Obviously, bitcoin/blockchain is the most asymmetric trade in a generation.

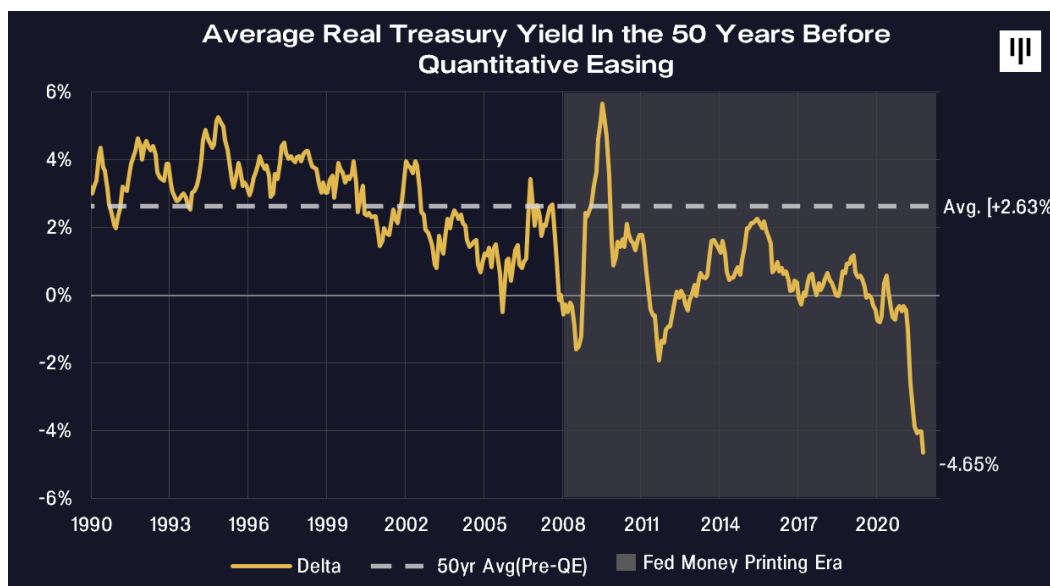
Bonds are the polar opposite. The potential upside is only a tiny fraction of the very real downside.

The U.S. 10-year note yields 1.34%. Even if the Fed drives the rate to zero – which is unlikely, but probably the furthest conceivable level – the price of the bond would only increase 13 percentage points. Now let's look at the downside . . .

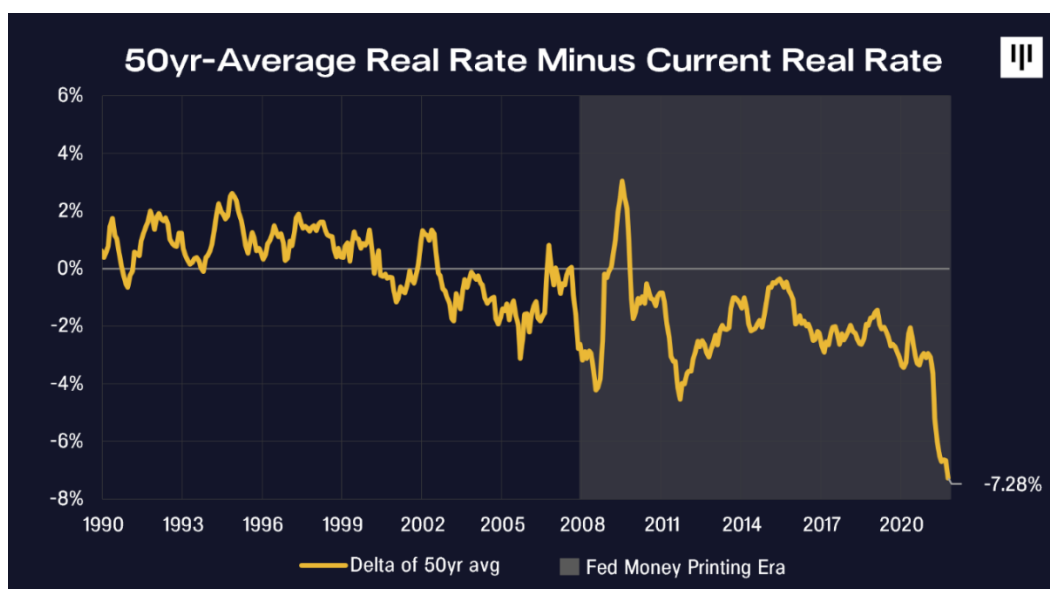
REAL RATES MASSIVELY NEGATIVE

The real rate of return is the yield a bond investor gets after inflation. For U.S. 10-year notes, the average real rate over the fifty years before money printing started (1957-2007) is 2.63%.

The Fed's decision to print half of our country's GDP and use it to push up the price of bonds has forced the real rate to negative 4.65%. (This obviously begs the question: Why would any economic actor want to buy something guaranteed to lose money?)



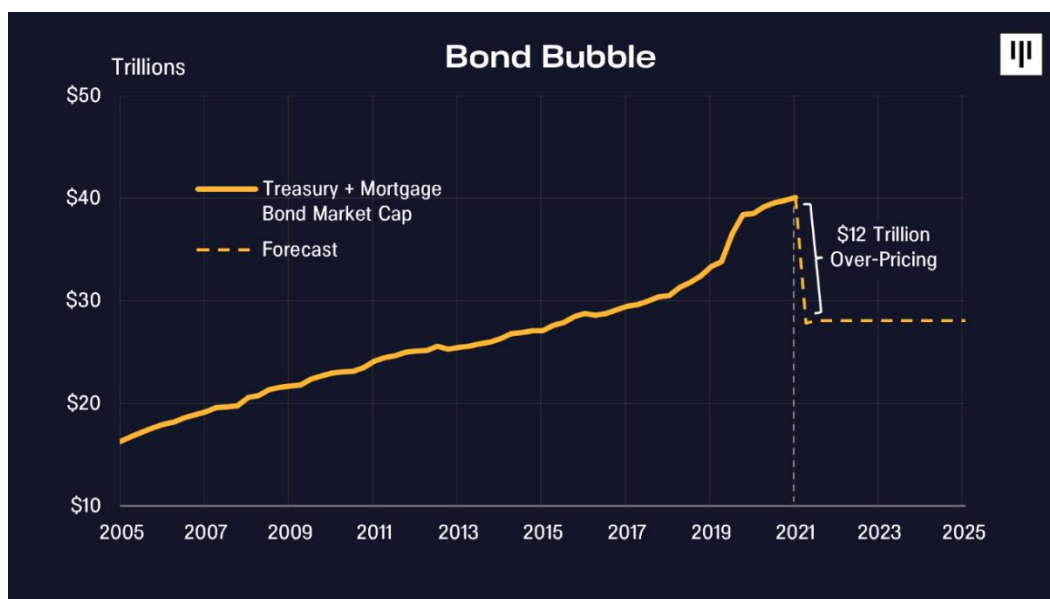
The best way to visualize just how extreme this manipulation has been is to graph the deviation of real rates from their 50-year average. The gray area is our brave new world of unlimited bond purchases. We are now an incredible 7.28 percentage points below average.



BOND BUBBLE BURST

Bonds investors are going to get absolutely destroyed when the Fed stops manipulating the bond market.

Here is the market cap of U.S. government and mortgage bonds. The huge short squeeze the Fed enacted is clear. It sent the value of bonds up \$10 TRILLION. When the Fed is forced to stop, bonds will fall.

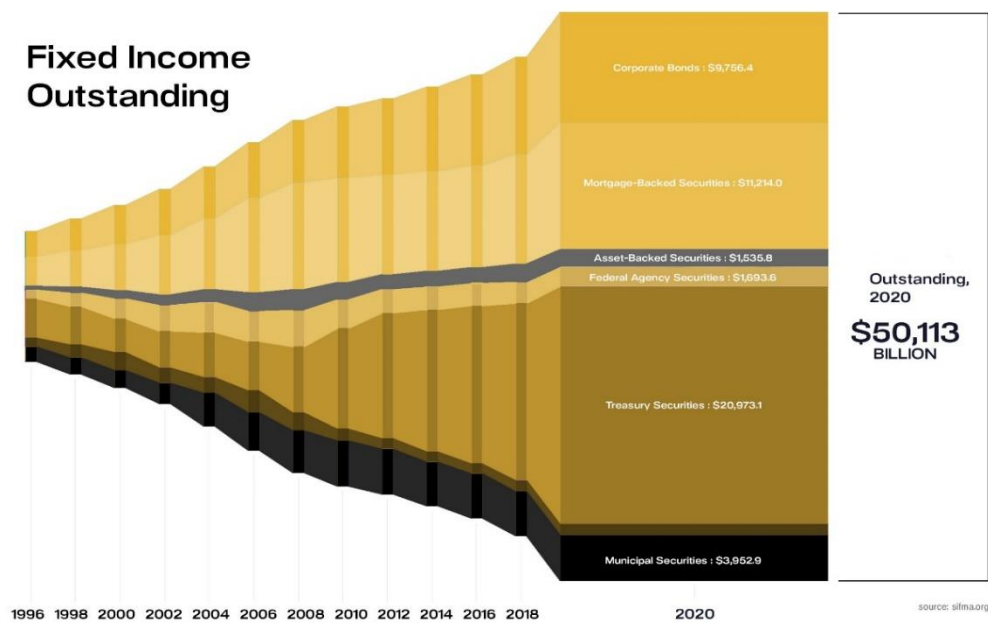
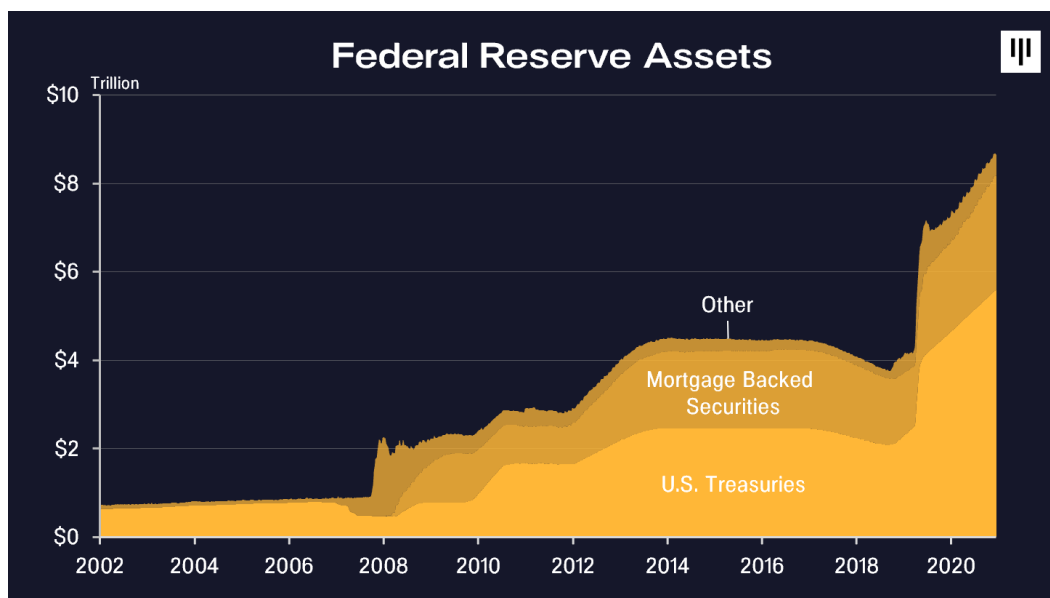


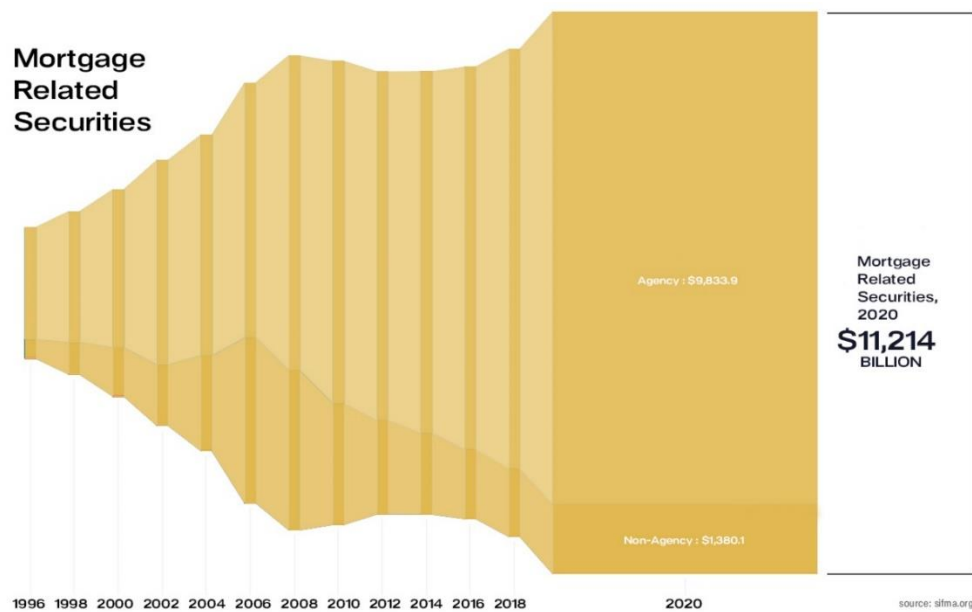
The dotted line in the above is what would happen if the real rates were no longer manipulated and they returned to the 50-year average. Bond market prices would fall 30 percentage points. This is against the maximum possible upside of 13. What if they only go halfway back to normal? \$6 trillion of market cap evaporating!

Buying crypto with only \$3 trillion market cap seems like a fantastic hedge.

FED BUBBLE BURST

These growth rates are unsustainable.



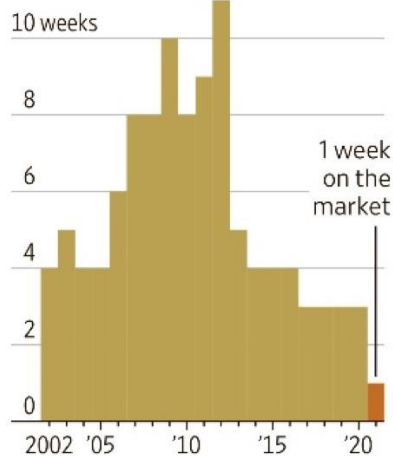


HOME PRICE INFLATION

The Fed's manipulation of the mortgage market is causing unprecedented problems.

In the 12 months ending in June 2021, the median time U.S. homes spent on the market before going under contract was only one week, according to a survey released by the National Association of Realtors. That marks a record low in data going back to 1989.

Median time U.S. homes spent on the market before a contract was signed.



Note: Data are for years ended in June.
Source: National Association of Realtors

That's insane. Why is the Fed ****still**** buying mortgage bonds? Trying to make that go negative?

FINANCIAL GRAVITY

If your institution hasn't already sold your bonds to the Fed, take the deal.

The Fed is not going to be able to overpay for your bonds forever. Take the gift.



Financial gravity will work the moment the Fed stops manipulating the market.

The bond bubble reminds me of a classic country song by Hank Williams, Jr. *It's All Over But The Crying*.

UPDATE ON CHINA MINING BAN

In our August letter we wrote:

Chinese policy is definitely shutting down mining in China. Our models show that up to 56% of the change could not be explained by price alone. 56% of a 45% drop is 25% of the previous total hardware power has been shut in by policy action.

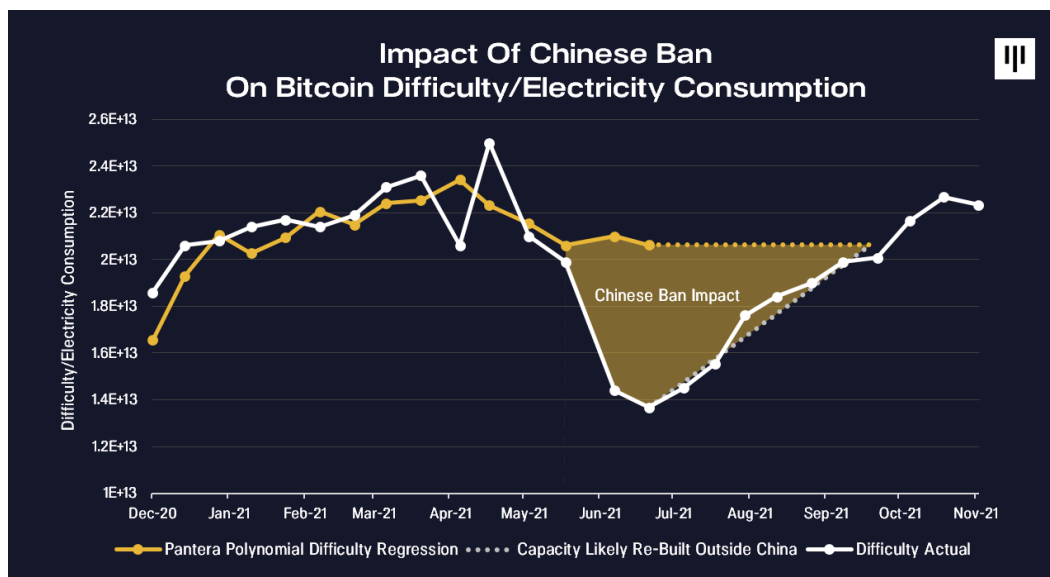
The fallout of this ban was a significant outside context event ($p < 0.00001$).

Command economies can shut in capacity by edict. Not in the free world. Bitcoin mining is hyper-competitive. The void will be replaced – and probably very quickly. Here we've graphically represented it as three months.

The shaded area of shut-in mining capacity is worth \$2.0 billion annually. (25% of the \$7.9bn above.)

That "free money" will be soaked up with mining rigs outside of China.

The recovery happened exactly as forecast. The network difficulty is above the level it was prior to the China ban on mining.



Although difficult to know with certainty, it seems very likely that much of the reboot in mining power is occurring in places with cleaner energy than those utilized by Chinese miners.

The transition to renewables is well underway.

September 8, 2021

BITCOIN HASHRATE RECOVERING AS FORECAST

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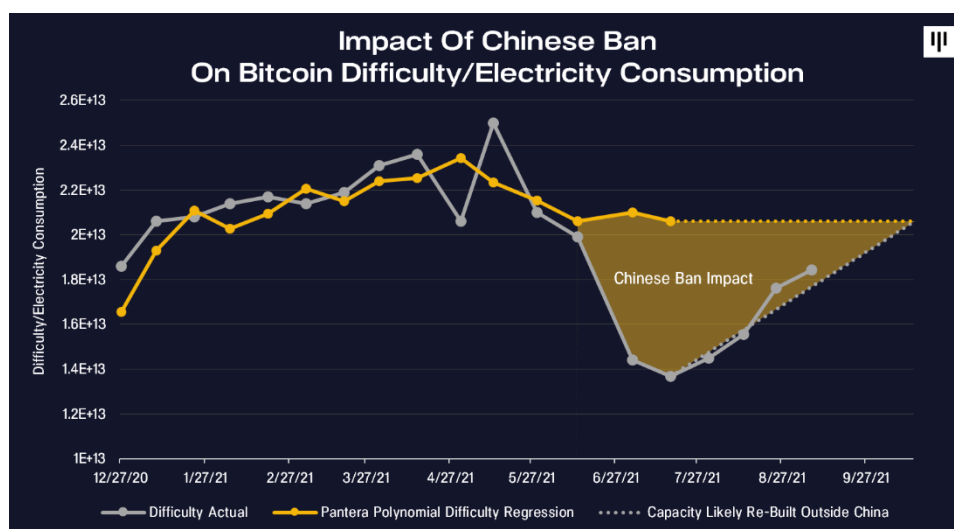
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That “free money” will be soaked up with mining rigs outside of China.

The recovery is happening exactly as forecast. The network has already recovered 68% of the drop in the hashrate that our polynomial regression attributed to the Chinese ban.



Although difficult to know with certainty, it seems very likely that much of the reboot in mining power is occurring in places with cleaner energy than those utilized by Chinese miners.

The transition to renewables is well underway.

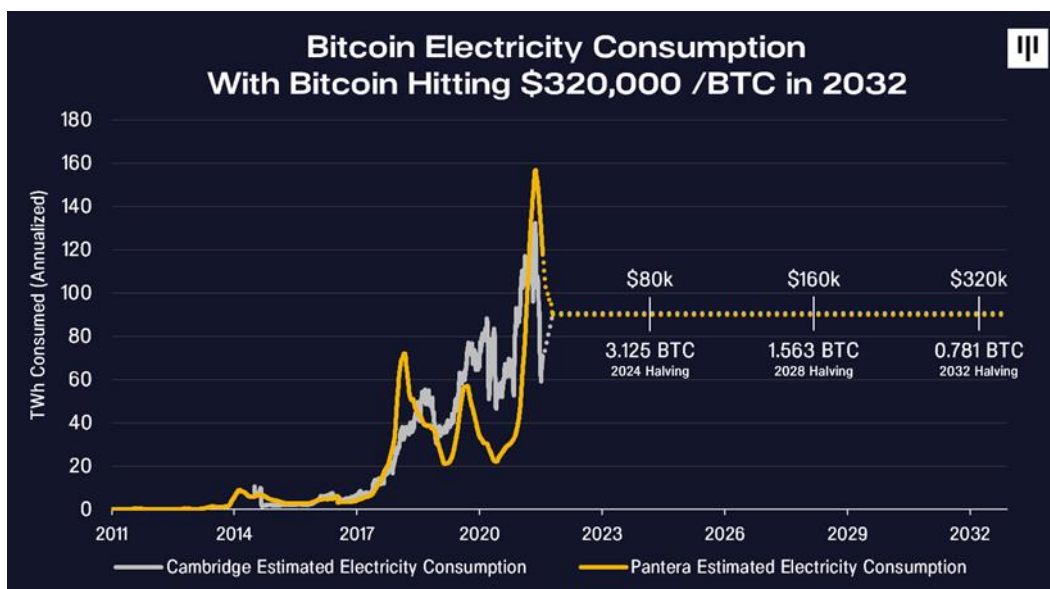
BITCOIN HALVINGS FORCE CUTS IN ELECTRICITY CONSUMPTION

I wanted to stress one important point:

Bitcoin has a built-in mechanism to reduce energy consumption over time. The number of bitcoin issued in the every-ten-minutes block reward is cut in half every four years. *Ceteris paribus*, the amount of electricity Bitcoin consumes will be cut by 50% every four years. For comparison, the Paris Accord only requires 7% cuts every four years.

Of course, I am not suggesting that the price of bitcoin holds here permanently. From a conceptual standpoint though, halvings will force a 50% reduction from whatever level would otherwise exist.

Perhaps a more realistic scenario is if the price of bitcoin were to double every four years in parallel with the halvings – putting bitcoin at \$320,000 /BTC in 2032 – electricity consumption would be no greater than it is today.



At that point it will probably be almost exclusively renewable/trapped – like hydroelectric, gas flares, geothermal, remote hydrocarbon deposits, etc.

August 4, 2021

E.S.G. IS THE LITTLE BIGHORN OF BITCOIN SKEPTICS

"Custer's Last Stand was an armed engagement between combined forces of the Lakota, Northern Cheyenne, and Arapaho tribes and the 7th Cavalry Regiment of the United States Army. The battle, which resulted in the defeat of U.S. forces, was the most significant action of the Great Sioux War of 1876. It took place on June 25–26, 1876, along the Little Bighorn River in the Crow Indian Reservation in southeastern Montana Territory."

– Wikipedia

Bitcoin skeptics have been fighting a losing war for over a decade. Battle after battle going against them. Some of the major battles include:

~~It'll Get Hacked~~

~~The Silk Road Guy Takes Bitcoin~~

~~Bitcoin Is A Fraud~~

~~The U.S. Marshall's Office Would Never Auction Bitcoin~~

~~It's A Bubble~~

~~The Exchanges Are Tiny Startups~~

~~Wall St. Won't Do Blockchain~~

~~Governments Won't Do Blockchain~~

~~There's No Regulated Custodian~~

When the *There's No Regulated Custodian Battle* fell to the combined forces of Fidelity, ICE's Bakkt, Coinbase, BitGo, and others – I thought the war was over. I was wrong.

A new battle has come roaring over the hill. The last stand.

Like General Custer thinking his Gatling gun invincible on the field of battle – so too the forces of Fear-Uncertainty-Doubt. They have recently brought out the ultimate weapon: ESG.

To be sure, it is a weapon so ominous that many forfeit the battlefield to avoid doing combat with it.

ESG stands for Environmental, Social, and Governance.

ESG		
Environmental	Social	Governance
• GHG Emissions • Energy Use and Efficiency • Air Pollutants • Water Use • Waste Management – Water, Solid, and Hazardous • Use of Ecosystems • Innovation in Environment-Friendly Products and Services	• Diversity and Equal Opportunity • Poverty and Community Impact • Supply Chain Management • Customer Privacy • Local Communities • Freedom of Association • Human Rights	• Code of Conduct and Business Principles • Accountability • Transparency and Disclosure • Board Diversity and Structure • Bribery and Corruption • Stakeholder Engagement • Shareholder Rights

It's gonna be an epic battle. And I'm not saying the E part of ESG doesn't have some credence on Bitcoin, but I think that when the smoke clears it will have been a rout. Bitcoin and other blockchains are wonderful for ESG. I believe Blockchain technology will have a profoundly positive impact on billions of peoples' lives – making it unambiguously positive from an ESG standpoint.

Nothing is utopia-perfect. Except for unconditional love, everything has a cost.

ESG :: COSTS VS. BENEFITS

"I think Sam [Englehardt] made an important point – that you have to weigh the costs versus the benefits. That's not part of the dialogue now.

Two main points would be:

Yes, Bitcoin does consume a lot of electricity. That's true. Most of the other blockchains use other consensus mechanisms that don't consume electricity. So, if you're going to talk about energy consumption, you should not focus on just one of the blockchains.

"The second one would be the whole phrase of ESG is supposed to include more things. If Bitcoin really does improve the lives of 3.5 billion people, financial inclusion, letting them have control over their own savings, that seems like the Social bit is pretty high. Might be a small negative on the E part of ESG, but Bitcoin is going to have a big positive impact on the S and G parts."

– Dan Morehead, Penn Blockchain Conference, April 23, 2021

We'll explore a few perspectives on those tradeoffs later in this letter – in Bitcoin and other blockchains and also in gold and the tech/data monopolies. Plenty of ESG sins to go around.

The recent debate just focusing on one blockchain (Bitcoin) and just one issue (Environment) – it ignores the wonderful Social and Governance benefits blockchain is bringing to billions of people. For populist politicians – who (rightly) hate centralized bank power – to think blockchain is not wonderful is something we should correct.

DIGITAL GOLD VS. OLD SCHOOL GOLD

First, I don't even debate the ESG-ness of "digital gold" (a.k.a. Bitcoin) with anybody who has ever owned old-school gold. Gold is like the maxed-out perfect trifecta of ESG horribleness.

I can't imagine an asset less ESG. Diesel smoke and toxic chemicals like sodium cyanide and sulfuric acid spilling out of open-pit strip mines and heavy metal pollutants in the tailings in some of the worst, most repressive kleptocracies on Earth.



For illustration, the chemical process used in modern gold mining is called "cyanide heap leaching". Let's just say, not very ESG at all.

Whatever ESG sins blockchain has, they are nothing compared to gold.

EVERYTHING HAS TRADEOFFS

"He that is without sin among you, let him first cast a stone."

– John 8:7

A quick take on the most valuable companies in America shows all is not ESG utopia.

- Apple's products are built exclusively in a country that ranks dead last in ESG and is the world's largest polluter – causing global warming.¹ Apple's products are all made of aluminum. Aluminum smelting consumes about three percent of the world's electricity – six times as much as Bitcoin.
- Facebook doesn't even have one-third of E.S.G. – corporate Governance. One guy controls the majority of voting shares. Serious Social questions result from that one man's ability to influence democratic elections, impact the lives and mental health of billions of people, etc.

The Judiciary Committee of the U.S. House of Representatives has recently found that the four largest (centralized) tech companies – those two plus Amazon and Google – abuse their monopoly positions.

SUBCOMMITTEE ON ANTITRUST,
COMMERCIAL AND ADMINISTRATIVE LAW
OF THE COMMITTEE ON THE JUDICIARY

¹ "China would be the lowest-ranked large market." - David Harris, Head of Sustainable Investment at the London Stock Exchange Group, parent of FTSE Russell

Although these four corporations differ in important ways, studying their business practices has revealed common problems. First, each platform now serves as a gatekeeper over a key channel of distribution. By controlling access to markets, these giants can pick winners and losers throughout our economy. They not only wield tremendous power, but they also abuse it by charging exorbitant fees, imposing oppressive contract terms, and extracting valuable data from the people and businesses that rely on them. Second, each platform uses its gatekeeper position to maintain its market power. By controlling the infrastructure of the digital age, they have surveilled other businesses to identify potential rivals, and have ultimately bought out, copied, or cut off their competitive threats. And, finally, these firms have abused their role as intermediaries to further entrench and expand their dominance. Whether through self-preferencing, predatory pricing, or exclusionary conduct, the dominant platforms have exploited their power in order to become even more dominant.

My point is that unless your organization has already divested from gold and the tech monopolies on ESG grounds, it would be highly inconsistent to rule out blockchain.

BITCOIN "MINING"

Unfortunately, in 2010 somebody on the BitcoinTalk Forum picked the word "miner" to describe the firms that process transactions and provide security to the Bitcoin network. The competing word at the time which lost out was "minting". While not great, "minting" would have been much less confusing. Bitcoin miners have nothing in common with real-world miners. They are basically the Visa/MasterCard of the system.

In real-world mining, if you double the hardware and fuel, you get double the newly-mined gold. If you doubled Bitcoin hardware and electricity, there would be no change in the new supply of bitcoin: 6.25 bitcoins every ten minutes.

Bitcoin was set up as a one-computer-one-vote governance system (known as Proof-of-Work). When my brother introduced me to Bitcoin in 2011, he was using a laptop. As the value of Bitcoin rose, it became rational to buy bigger and bigger "computers". Now the Bitcoin network is processed on a huge array of 300-megawatt datacenters.

BITCOIN CAN USE ENERGY THAT OTHER INDUSTRIES CAN'T

Miners all use the same chips. Literally, their only competitive advantage is sourcing the least expensive energy on Earth. They have massive incentives to find trapped energy that others cannot use.

"Another key factor that makes Bitcoin's energy consumption different from that of most other industries is that bitcoin can be mined anywhere. Almost all of the energy used worldwide must be produced relatively close to its end users – but Bitcoin has no such limitation, enabling miners to utilize power sources that are inaccessible for most other applications."

"Hydro is the most well-known example of this. In the wet season in Sichuan and Yunnan, enormous quantities of renewable hydro energy are wasted every year. In these areas, production capacity massively outpaces local demand, and battery technology is far from advanced enough to make it worthwhile to store and transport energy from these rural regions into the urban centers that need it. These regions most likely represent the single largest stranded energy resource on the planet, and as such it's no coincidence that these provinces are the heartlands of mining in China, responsible for almost 10% of global Bitcoin mining in the dry season and 50% in the wet season."

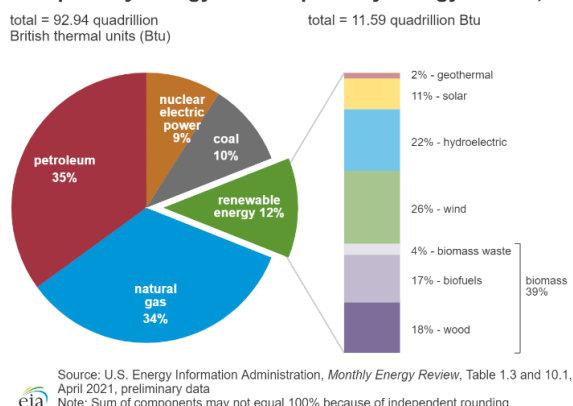
"Regions with the capacity to produce more energy than could be consumed locally, such as Iceland, Sichuan, and Yunnan, became net energy exporters through aluminum – and today, the same conditions that incentivized their investment in smelting have made those locations prime options for mining bitcoin. There are even a number of former aluminum smelters, such as the hydro Alcoa plant in Massena, NY, that have been directly repurposed as Bitcoin mines."

– Nic Carter, *How Much Energy Does Bitcoin Actually Consume?*, Harvard Business Review, May 5, 2021

Bitcoin already has one of the highest proportions of renewable energy among all industries. On the low end of the spectrum, Cambridge Center for Alternative Finance estimates that 39% of Bitcoin's energy outlay

derives from renewables². Most estimates are in the 40-60% ranges. Some as high as 73%. By comparison, only 12% of energy is from renewable sources in the United States as a whole.

U.S. primary energy consumption by energy source, 2020



GODZILLA VS. MOTHRA

I wrote last month that a convergence of things caused the blockchain markets to go down sharply. The two most impactful were:

- China bans Bitcoin
- Elon Musk's 180

This whole Chinese Red Army vs. Elon Musk thing is like a *Godzilla vs. Mothra* battle. Two supersized power titans doing chaotic battle – over Twitter no less!

Having seen China ban Bitcoin three times already in my career, I must admit I was dubious.

That's really the last kind of sketchy thing about Bitcoin. It's very clear that miners outside China use a much higher fraction of renewable energy than the rest of their societies. It's probably also true inside China, but since there's no data from China, you can't prove it.

Bitcoin marketing pitches basically end when you get the ol'

"But, what about coal-burning Chinese Bitcoin miners?"

It would be nice to have that go away.

It looks like it is. Our analysis indicates that there is 31% less mining/energy consumption today than would have been predicted solely by the price movement. It does seem that the Chinese policy action is taking a big bite out – as much as half of their total capacity already. If they do really shut down Chinese Bitcoin mining, that would be awesome for our asset class.

I made it eight years without ever mentioning the words "Elon" or "Musk" in our investor letter. This will be the second time in three months, but I have to admit he came up with an absolutely classic line.

When stating publicly for the first time that in addition to Tesla Motors still owning bitcoin – that he personally and SpaceX Corp. have also bought – and are still long – bitcoin, he said:

"I might pump, but I don't dump."

– Elon Musk, *Bitcoin as a Tool for Economic Empowerment*, The B Word Conference, July 21, 2021

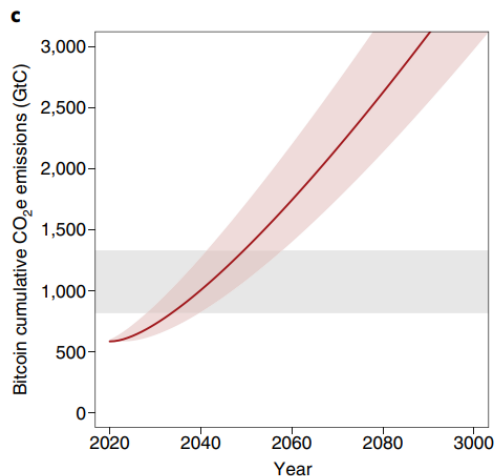
ACAMEMIC F-U-D

² Cambridge Center for Alternative Finance, *3rd Global Cryptoasset Benchmarking Study*, <https://www.jbs.cam.ac.uk/faculty-research/centres/alternative-finance/publications/3rd-global-cryptoasset-benchmarking-study>

Random nuts on Twitter spreading misinformation (Fear, Uncertainty, and Doubt) is expected. Academics really should be above that. This academic paper is still one the most frequently cited on Bitcoin energy consumption:

***"Bitcoin Emissions Alone
Could Push Global Warming Above 2° C"***

"The cumulative emissions of such usage growth could fall within the range of emissions likely to warm the planet by 2° C within only 16 years (red line). The cumulative emissions of Bitcoin usage will cross the 2° C threshold within 22 years if the current rate is similar to some of the slowest broadly adopted technologies, or within 11 years if adopted at the fastest rate at which other technologies have been incorporated (that is, the red area).



"Certainly, high electricity cost will push the development of more efficient hardware. However, reducing Bitcoin's carbon footprint should not rest solely on some yet-to-be-developed hardware but include simple modifications to the overall system, such as adding more transactions per block or reducing the difficulty or time required to resolve the proof-of-work – both of which could result in immediate electricity reductions for Bitcoin usage."

– Nature Climate Change, *Bitcoin Emissions Alone Could Push Global Warming Above 2°C*, October 2018

Uh...no...none of those things has anything to do with Bitcoin energy consumption.

Transactions don't drive electricity. Time between blocks doesn't drive electricity. Electricity is driven solely by the price of bitcoin. We'll dive into that soon.

BEEN THERE, DONE THAT

First, a couple of quick ones. The author misses the whole theme-iness of Bitcoin. The entire appeal is precisely that it doesn't change.

His suggested changes are so simple they have in fact been tried a thousand times.

That's not an exaggeration. There are a thousand so-called alt coins. These alternatives to Bitcoin have tried all those changes. Litecoin, for example, is among the first. The time between blocks is four times faster – a new block every 2.5 minutes. If that mattered it would be the dominant blockchain. The annual block reward for Litecoin is just \$362 million. Bitcoin's annual issuance is \$13.1 billion. Litecoin's annualized block reward is just 2.8% of the value of Bitcoin's.

One hundred million people voted on the feature set – Bitcoin.

MOORE'S LAW ON CRACK

"However, reducing Bitcoin's carbon footprint should not rest solely on some yet-to-be-developed hardware."

Again, this has already happened. New hardware has been developed at an astounding rate for over a decade. Since January 1, 2014 Bitcoin mining hardware has increased power 11.4x every two years. That's Moore's Law on crack.

NEGATIVE NEWS SELLS

I get it. Newspapers have to write negative stuff to pay salaries. Nobody wants to buy a newspaper with this headline:

***8% Of All U.S.-Mexico Remittance Now Goes Over Bitcoin
Millions Of Migrants No Longer Have To Work A Month
To Pay Their Remittance Company***

(This is true. Our portfolio company in Mexico called Bitso is already serving two million people – saving them a month's wages every year.)

It's way easier to sell newspapers with FUD like this:

***Researchers At Cambridge University Estimate That Mining Bitcoin
Uses More Electricity Than Entire Countries Like Argentina Do***

– Hiroko Tabuchi, *In Coinbase's Rise, a Reminder: Cryptocurrencies Use Lots of Energy*, The New York Times, April 14, 2021

The essence of good writing is distilling complex issues into tight sentences. Oscar Wilde was a master. The sentence that followed that New York Times headline really captures it:

"All this accounts for so little of the world's total transactions, yet has the carbon footprint of entire countries. So, imagine it taking off – it'll ruin the planet."

– Camilo Mora, The New York Times, April 14, 2021

Yes, that's our Camilo Mora from above – still being paid by the University of Hawaii at Manoa to spew nonsense. In just one sentence the author was able to get so much that is important backward. It's very useful in highlighting some of the chief fallacies that Bitcoin skeptics promote.

The number of transactions is totally irrelevant. This academic has the causality completely backward.

*Every ten minutes a fixed number of bitcoin are issued. That's it.
It doesn't matter if every Starbucks transaction on Earth went over Bitcoin.
It doesn't matter if every Chinese Bitcoin miner got unplugged.
There's no Greenspan Put if the housing or stock market crashes.
Global pandemic? Doesn't matter.
Every ten minutes 6.25 bitcoins are issued. That's it.*

It was originally 50 bitcoins every ten minutes. Every four years the number is cut in half. In 2012 it went to 25 bitcoins. 2016 to 12.5. Last May it halved to 6.25 bitcoins every ten minutes.

This "halving" is a mega-important point to which we will return.

Satoshi couldn't have made it any simpler.

Every ten minutes 6.25 x \$40,000 – \$250,000 worth of bitcoin are issued.

So, every ten minutes miners spend, on average, \$250,000 on chips and electricity. (Capitalism is a thing of beauty.)

Annually that adds up to \$13.1 billion. That's it. That is all the money available to buy energy and chips. That's what drives, and thus caps, electricity consumption.

If the entire world switched to Bitcoin today, it would have absolutely no impact on energy consumption, much less "ruin the planet".

OBFUSCATING REALITY

This elegant simplicity forces those who have an ax to grind to really work at it to overcomplicate and obfuscate reality. And obfuscate they do. Here's one example:

tion levels and growth trajectories that result from such comparisons.

Third, Mora et al. applied outdated values for mining rig efficiencies and electric power CO₂ intensities, which inflated their estimated 2017 Bitcoin energy use and CO₂ emissions values considerably. When estimating the direct electricity use of Bitcoin mining, the authors included in their selection pool many old and inefficient rigs that were no longer economically viable in 2017 (Supplementary Fig. 5). Furthermore, Mora et al. provided equal weighting when selecting a rig from their pool as the sole rig type to mine a block, thus over-representing slower, inefficient rigs and creating scenarios that require physically impossible rig counts. When we excluded unprofitable rigs in our replicated analysis, Mora and colleagues' model produced an estimate of 28 TWh in 2017 (Supplementary Fig. 6), which is one-quarter of their original estimate of 114 TWh. Furthermore, they applied 2014 CO₂ intensities (in gCO₂/kWh⁻¹) to calculate 2017 emissions, ignoring non-negligible grid decarbonization improvements in the intervening years (Supplementary Fig. 7)¹⁰, despite sufficient data being available at the time of their study for reasonable estimates of 2017 power mixes^{11,12}. Applying more reasonable 2017 electricity use and CO₂ intensity values in their model produced an estimate of 15.7 MtCO₂e, far lower than their original estimate of 69 MtCO₂e.

Fourth, by analytical design, Mora et al. applied 2017 per-transaction energy use and CO₂ emissions values in all future years, multiplied by annual transactions (Supplementary Equation (2)). This decision effectively held both mining rig efficiency and grid CO₂ intensities constant for the next 100 yr (Supplementary Fig. 7). This unprecedented choice ignores the dynamic nature of mining

Overcomplicating to the point of complete obscurity. First, all the parameters of Bitcoin miners' businesses are unknowable. These actors in a hypercompetitive sector must hide all their data, like rig efficiency, to stay a razor's edge ahead of the competition.

Assuming the same emissions from Bitcoin as from legacy industries and transportation is both wrong now and really wrong 100 years out. Assumptions that Bitcoin miners use the same energy mix as the wider economy is provably false today. Extrapolating that out for 100 years is silly.

We already know that today's fuel types are very different than society as a whole and over time will skew much more to trapped and renewable energy sources.

THE RECIPE FOR MAKING BITCOIN :: SILICA + ENERGY

Simplicity is best. Simplicity works in one energy formula:

$$E = mc^2$$

The Bitcoin energy formula is equally simple.

The two main ingredients for making aluminum are alumina and electricity. Similarly, the two main ingredients for making bitcoin are silica and electricity. The main costs miners pay are for silica chips and energy.

Recipe For Making Bitcoin

2 parts hardware
3 parts electricity

We use this formula to build our estimates of electricity consumption. Over time miners will spend 60%³ of the value of newly issued bitcoins (the block reward) on electricity.

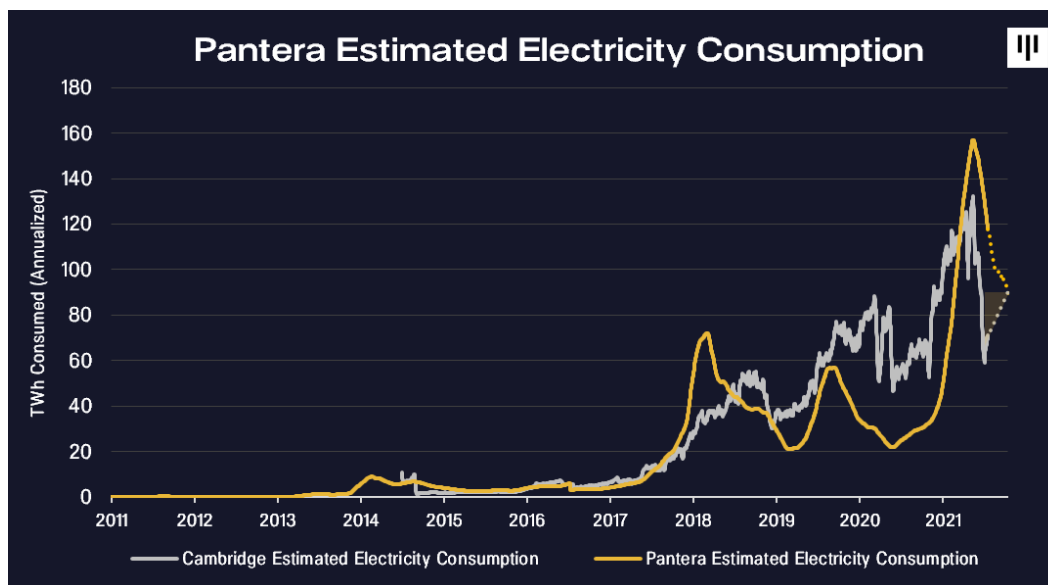
Thus, the energy formula for Bitcoin is:

$$E = 6.25 * \$/\text{BTC} * 60\%$$

³ 60.19%, *Bitcoin Energy Consumption Index*, <https://digiconomist.net/bitcoin-energy-consumption/>

The energy consumed in Bitcoin is, on average, equal to the value of the 6.25 bitcoins issued times the percentage of miners' total cost which is spent on energy (60%).

This simple formula – using a 90-day trailing average of the price – yields a very good fit of electricity consumption.



Inserting today's numbers:

$$E = 6.25 \times \$40,000 \times 60\% = \$150,000$$

Miners would be able to spend 60% of that or \$7.9 billion on electricity annually.

DEBUNKING MORA

As an aside, the amount of misinformation out there is hysterical.

In reading an academic paper debunking the Mora *et al* paper cited above, I was floored by how many logical mistakes were in there too.

"History has shown that poorly constructed scenarios of future IT energy use (often a result of overly simplistic extrapolations of early rapid growth trends) can spread misinformation and drive ill-informed decisions.

[Editor's Note: Amen! I'm worried that unchecked misinformation might cause bad policy decisions here.]

"Second, all three Bitcoin adoption scenarios designed by Mora et al represent sudden and improbable departures from historical trends in Bitcoin transactions.

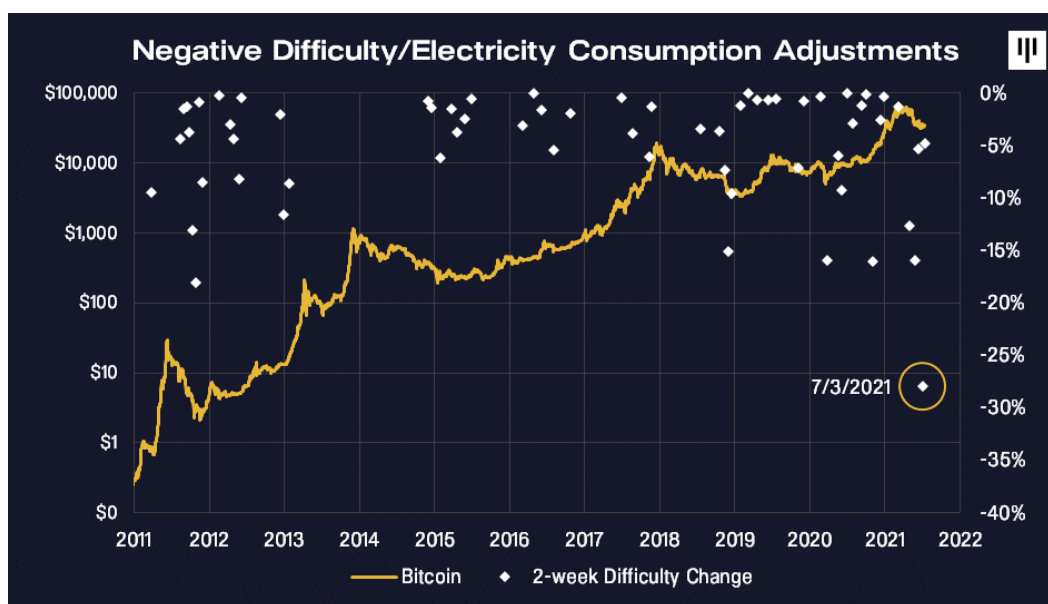
– Nature Climate Change, *Implausible Projections Overestimate Near-Term Bitcoin CO2 Emissions*, September 2019

Again, the wrong concept is that the number of transactions has anything to do with energy consumption. Energy consumption is solely a function of the price of bitcoin.

EMPIRICAL PROOF

We've just concluded an experiment to prove that electricity consumption is not in any way related to the number of transactions.

Bitcoin mining/electricity consumption has just seen the largest drop in history. The single largest negative difficulty adjustment was on July 3rd – dropping 28%. Adjustments occur every two weeks and the cumulative peak-to-trough drop since May is 45%.



We just unplugged half of all mining power globally and, NOTHING happened – no change in the number of transactions, security, nothing.

If Mora was right that increasing energy use was going to ruin the planet – having just seen energy consumption cut by more than half, we should be enjoying world peace by now.

Every four years the Bitcoin halving will do that same thing – remove half of mining/energy consumption. We'll return to this wonderful fact later.

DIFFICULTY AS A FUNCTION OF PRICE

Another way to prove energy is a function of price is to run a polynomial regression.

The R^2 of this regression is 79.7%. (R-squared is the proportion of the variation in the dependent variable (energy consumption) that is predictable from the independent variable (bitcoin price)).

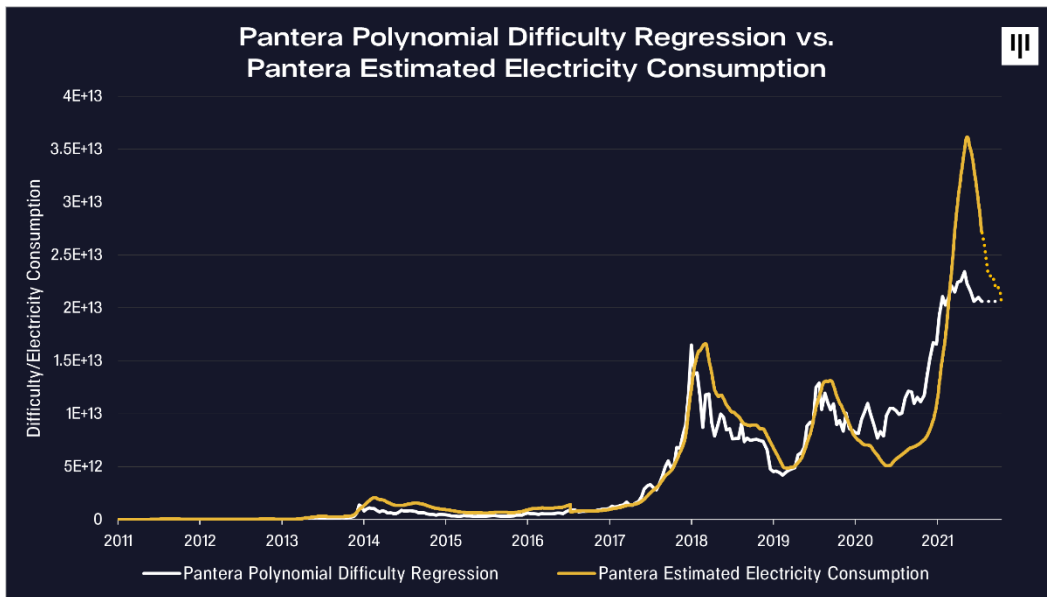
I've run a million regressions in investing over the decades. Almost none have been so conclusive.

Bitcoin Energy – f (price)

$$\text{Difficulty} = 0.212 p^3 - 28,640 p^2 + 1332521844 p$$

$$R^2 = 79.7\%$$

It is very comforting that both of our energy models yield very similar results.



Postulate:

Energy is a function of price

The polynomial regression proved that difficulty is a function of price

By the transitive property:

Electricity - Difficulty

We'll use those terms interchangeably - difficulty/electricity.

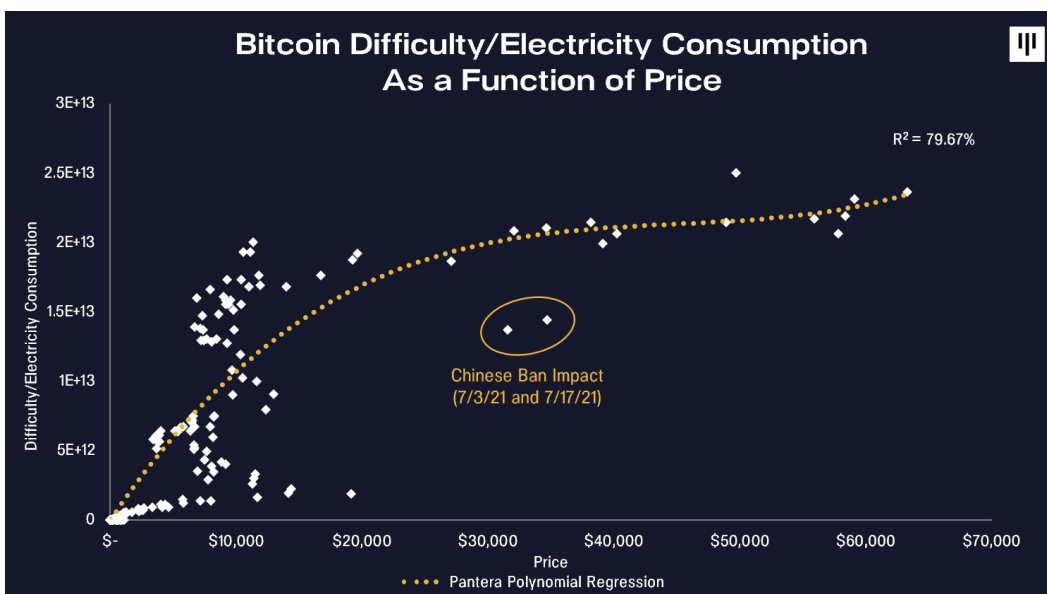
CHINESE BAN IMPACT

Plotting actual difficulty against our regression shows a very tight fit.

That polynomial regression clearly shows an outlier.

"One of these things is not like the others."

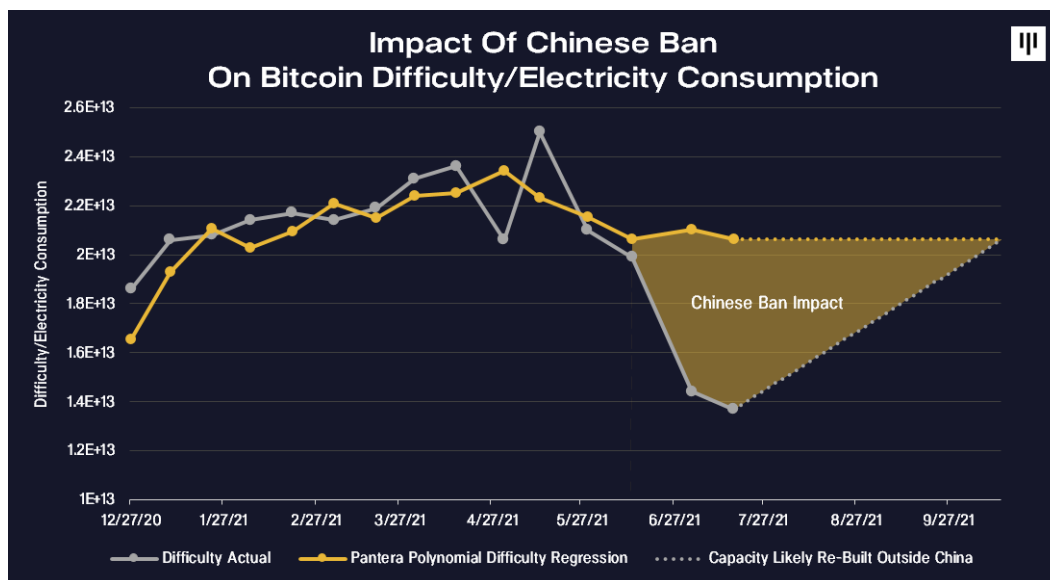
- Sesame Street



Chinese policy is definitely shutting down mining in China. Our models show that up to 56% of the change could not be explained by price alone. 56% of a 45% drop is 25% of the previous total hardware power has been shut in by policy action.

The fallout of this ban was a significant outside context event ($p < 0.00001$).

Command economies can shut in capacity by edict. Not in the free world. Bitcoin mining is hyper-competitive. The void will be replaced – and probably very quickly. Here we've graphically represented it as three months.

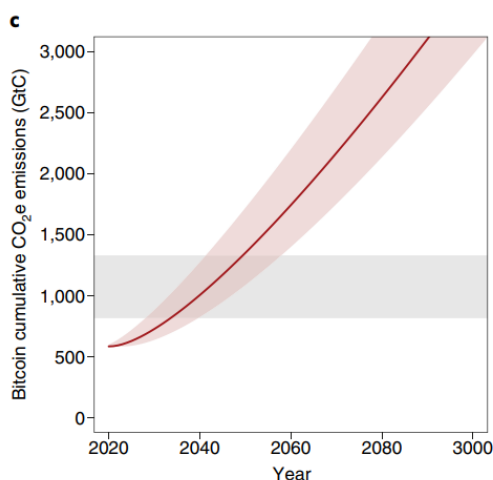


The shaded area of shut-in mining capacity is worth \$2.0 billion annually. (25% of the \$7.9bn above.)

That “free money” will be soaked up with mining rigs outside of China.

BITCOIN HALVING

Forecasting exponentially upward-sloping increases in consumption to the point of boiling the Earth may sell newspapers and get academic grants, but it's not right. (Nor is that axis. The year 2100 comes twenty years after 2080 – not the year 3000!)



Forecasting Bitcoin energy consumption is easy.

At a constant bitcoin price, one can forecast the amount of electricity Bitcoin consumes in any year in the future with incredible accuracy. It's already known.

If prices hold steady, the annual block reward would be \$13.1 billion for the next three years. Miners would be able to spend 60% of that, or \$7.9 billion, on electricity.

Our energy formula above:

$$E = 6.25 * \$/BTC * 60\%$$

Every four years the amount of bitcoin issued gets cut in half. In 2024 the energy formula will be:

$$E_{2024} = 3.125 * \$/BTC * 60\%$$

After the 2024 halving, miners will only have half today's amount - \$3.9 billion - to spend on electricity.

Ceteris paribus, the amount of electricity Bitcoin consumes will be cut by 50% every four years. For comparison, the Paris Accord only requires 7% cuts every four years.

Of course, I am not suggesting that the price of bitcoin holds at \$40,000 permanently. From a conceptual standpoint though, halvings will force a 50% reduction from whatever level would otherwise exist.

Perhaps a more realistic scenario is if the price of bitcoin were to double every four years in parallel with the halvings - putting bitcoin at \$320,000 /BTC in 2032 - electricity consumption would be no greater than it is today.

At that point it will probably be almost exclusively renewable/trapped - like hydroelectric, gas flares, geothermal, remote hydrocarbon deposits, etc.



BLOCKCHAIN ESG :: E DECLINING

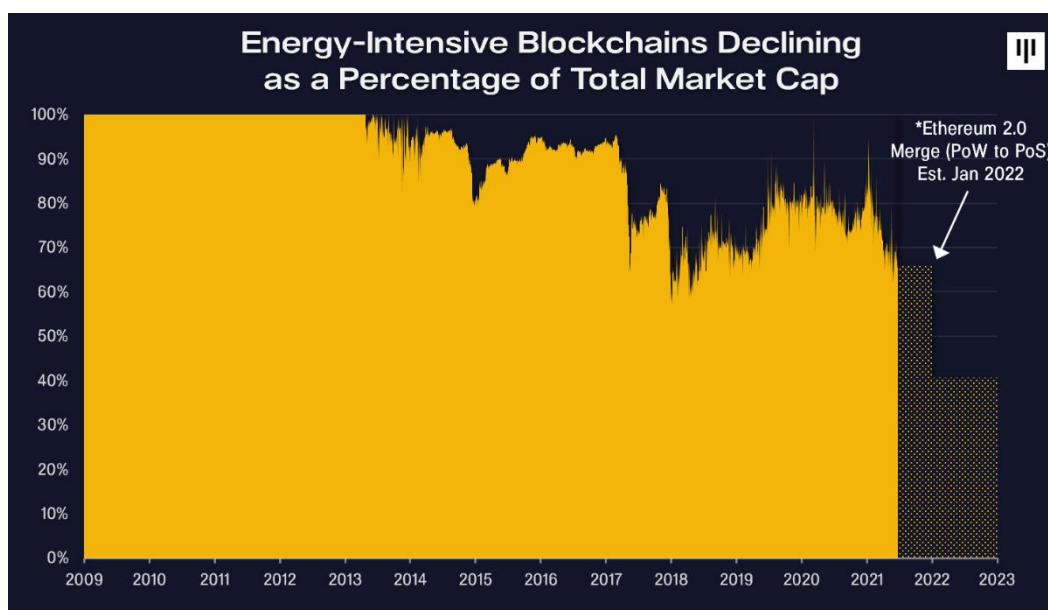
The energy intensity of other blockchains and the blockchain industry as a whole is already declining. It is well known that Bitcoin uses electricity to provide security. That consensus mechanism is known as Proof-of-Work.

Most newer blockchains do not. They use other consensus mechanisms which do not consume electricity. The most popular is Proof-of-Stake. Proof-of-Stake is basically one-share-one-vote, like in corporate securities.

In the early days, Bitcoin was the only blockchain. So, 100% of the blockchain industry was energy-intensive Proof-of-Work. In 2012, alternative consensus mechanisms which don't consume electricity - like Ripple - came out. They now represent 34% of the industry.

In early 2022, Ethereum will transition from Proof-of-Work to Proof-of-Stake, bringing along smart contracts and ERC-20 tokens that represent significant value in the blockchain ecosystem.

After that change, 57% of blockchain market cap will not be energy-intensive.



DON'T FORGET THE S AND THE G

The recent ESG uproar has spent an inordinate amount of energy discussing the E in ESG, which is certainly an issue that shouldn't be taken lightly. But the conversation shouldn't end there – it's important to dig deeper into blockchain's relationship with the other two-thirds of the acronym. In our view, the total effect is unequivocally positive.

First, blockchain is a powerful tool for achieving social objectives. To take one example, the open finance revolution underpinning many of today's DeFi innovations is designed to "bank the unbanked" and give users financial autonomy. While there's much more work to be done on this front, early use cases – such as offering lower-fee remittances for families across borders and banking pro-democracy activists in hostile nations and – are beginning to deliver on this promise. As the ecosystem's building blocks continue to mature, new pro-social applications will be enabled by the blockchain, from highly efficient charities to seamless carbon offsets.

Second, the concept of governance is being radically challenged in a way that, we believe, is positive for everyone involved. For one, transparency and on-chain accountability are an integral part of the DNA of many of the space's most successful projects; traditional concerns around corruption and shady behavior can be simply validated by globally accessible information. Many projects are even taking this concept of radical openness and "rules without rulers" to its logical conclusion by organizing themselves as a decentralized autonomous organization (DAO) instead of a traditional corporation. This idea is no longer theoretical: Uniswap, a leading project with over \$20 billion in market capitalization, effectively operates as a DAO. Moving forward, blockchain will give entrepreneurs across all industries new tools for approaching governance. The result will be projects that have stronger incentive-alignment between participants, promote a more meritocratic process, and optimize for longevity.

The S and G portions are true strengths of blockchain—through decentralized governance, expanding financial access, etc.—that often are de-emphasized in ESG discussions.

FULL-SPECTRUM ESG

Those who wish to spew Fear-Uncertainty-Doubt focus entirely on just one letter in ESG. Any serious, full-spectrum ESG analysis of blockchain will conclude that blockchain is wonderful for ESG. Blockchain will provide such wonderful benefits to billions of people.

"To some extent, the energy consumption in Bitcoin is a real issue. You can have intelligent debates about how much is renewable. I'm fine with that. I feel like the new ESG thing, which you didn't hear a year ago, might be because we've crossed everything else off the list. Right?"

There was the Silk Road guy using Bitcoin, and we crossed that off the list. There're no custodians that are regulated, we crossed that off the list. What's the CFTC going to do? What's the OCC going to do? We crossed all these other things off the list. You're kind of left with ESG. What about that one? I think that is part of it. Let's focus a bit more on the S and G, not exclusively the E."

– Dan Morehead, Penn Blockchain Conference, April 23, 2021

BLOCKCHAIN ESG SCORECARD

Social

- Diversity and Equal Opportunity – the essence of Bitcoin is it's permissionless. Anybody with a smartphone can participate. 3.5 billion people have equal opportunity.
- Poverty and Community Impact – migrants no longer forced to pay a month's wages a year to their remittance company
- Freedom of Association – permissionless access is the ultimate freedom of association

Governance

- Code of Conduct and Business Principles – its code is code!
- Transparency and Disclosure – the code is open source and every Bitcoin transaction that has ever happened is published every ten minutes to anyone who wants to view it. Literally can't get more transparent.
- Board Diversity and Structure – anyone with a smartphone can participate, the ultimate diversity and inclusion
- Stakeholder Engagement – each blockchain community has complete control of their project
- Shareholder Rights – all rights are enshrined in code

ESG Scorecard Blockchain			
	E	S	G
Bitcoin	?	✓ ✓	✓ ✓
Other Blockchains	✓	✓ ✓	✓ ✓
Blockchain Venture	✓	✓	✓

HOW MUCH ENERGY SHOULD A MONETARY SYSTEM CONSUME?

Even the appropriate amount of energy consumption of Bitcoin is a non-obvious question.

Nic Carter said it well:

"According to the Cambridge Center for Alternative Finance (CCAF), Bitcoin currently consumes around 110 Terawatt Hours per year – 0.55% of global electricity production, or roughly equivalent to the annual energy draw of small countries like Malaysia or Sweden. This certainly sounds like a lot of energy. But how much energy should a monetary system consume?"

"How you answer that likely depends on how you feel about Bitcoin. If you believe that Bitcoin offers no utility beyond serving as a Ponzi scheme or a device for money laundering, then it would only be logical to conclude that consuming any amount of energy is wasteful. If you are

one of the tens of millions of individuals worldwide using it as a tool to escape monetary repression, inflation, or capital controls, you most likely think that the energy is extremely well spent. Whether you feel Bitcoin has a valid claim on society's resources boils down to how much value you think Bitcoin creates for society."

– Nic Carter, *How Much Energy Does Bitcoin Actually Consume?*, Harvard Business Review, May 5, 2021

BOTTOM LINE :: BITCOIN IS WONDERFUL FOR ESG

I can imagine a day when billions of people use Bitcoin and other blockchains.

- Billions of people now have their savings protected from constant devaluation, bank failures, government seizures
- Migrants no longer work for a month to pay their remittance company
- The average restaurant almost doubles its profit margin/stays alive because it is no longer forced to hand almost half of its profit to the credit card duopoly
- Billions of workers join the global economy by being paid in borderless cryptocurrency
- Voters have certainty their vote is counted – because they can see it on the blockchain
- Refugees get 100% of the aid intended for them – not the scraps left over after most is stolen
- Financial inclusion brings billions into the world of secure money, savings, and investment

Satoshi bequeathed all this to society – open source, not patented, and has never used a dime for his/her/its own profit.

Blockchain is unambiguously good.

Someday we'll look back and wonder:

"Wasn't that time in the Twenties really weird when people were pushing the agenda that blockchain was BAD for ESG?!?!?"

BLOCKCHAIN ESG READING

For those that want to read more about blockchain ESG, here are some good papers.

- [How Much Energy Does Bitcoin Actually Consume?](#) (Nic Carter, *Harvard Business Review*)
- [The Last Word on Bitcoin's Energy Consumption](#) (Nic Carter, *CoinDesk*)
- [The Frustrating, Maddening, All-Consuming Bitcoin Energy Debate](#) (Nic Carter, *CoinDesk*)
- [Bitcoin is Key to an Abundant Clean Energy Future](#) (Square & ARK Invest)
- [The Humanitarian And Environmental Case For Bitcoin](#) (Alex Gladstein, *Bitcoin Magazine*)
- [Uncovering The Hidden Costs Of The Petrodollar](#) (Alex Gladstein, *Bitcoin Magazine*)
- Aker Shareholder Letter
- [Bitcoin As Battery](#) (Nick Grossman)
- [Think BTC is a Dirty Business? Consider the Carbon Cost of a Dollar](#) (Susan Su, *Climate Money*)
- [A Closer Look at the Environmental Impact of Bitcoin Mining](#) (Christopher Bendiksen, *CoinShares*)
- [Green Innovation in Bitcoin Mining: Recycling ASIC Heat](#) (Brains)
- [Is Bitcoin ESG Friendly for Equity Investors?](#) (AllianceBernstein, William Johnston)
- [Climate and Crypto](#) (Continuations)
- [Understanding Bitcoin's Energy Use](#) (Peter Van Valkenburgh, *Coin Center*)
- [On Bitcoin's Energy Consumption: A Quantitative Approach to a Subjective Question](#) (Rachel Rybarczyk, Drew Armstrong & Amanda Fabiano, *Galaxy Digital Mining*)
- ['Bitcoin Is the Revolution': An Interview With Alex Gladstein](#) (Sophia Zaller, *CoinDesk*)

- [Realistic Assessment In View Of ESG And Rapidly Growing In Scale](#) (Chetan Woodun, Seeking Alpha)
 - [Implausible Projections Overestimate Near-Term Bitcoin CO2 Emissions](#) (Nature)
 - [A Different View on Bitcoin's Energy Consumption](#) (Paul Veradittakit, Pantera Capital)
 - [Bitcoin Emissions Alone Could Push Global Warming Above 2°C](#) (Nature)
-

June 14, 2021

BLOOMBERG INTERVIEW WITH ERIK SCHATZKER

Q. Dan, all of a sudden, Elon Musk, one of the biggest crypto boosters in the corporate world has issues with Bitcoin. Does that concern you?

"He's obviously a mercurial person and changing corporate strategy very quickly here. It's important to note that Tesla's still long the \$1.5 billion of bitcoin that they bought."

Q. You surely saw his tweet in which he said, "Crypto is a good idea on many levels and has a promising future, but the environmental cost of all the coal burned to mine Bitcoin is simply too great." Does he have a point about that in your view?

"There is a point to think about – How renewable are the resources that are used to process transactions on the Bitcoin-brand blockchain? But it's very important to remember Bitcoin is only one of many blockchains. It's about 40% of the overall market capitalization. The other 60% are coins that either currently use no electricity or will switch to proof-of-stake mechanisms that won't use electricity."

Q. Does that mean Bitcoin's future is by definition dimmer? I'm not playing on the electricity theme, but dimmer than the future for those other tokens? Especially among institutional investors, right?

"It will have some impact. ESG concerns have come up in the last three or four months...It's an interesting topic, but the majority of blockchains in this space don't use electricity so it shouldn't be a big issue for the industry as a whole."

Q. What if the US government finally cracks down on crypto, either as a means of exchange or cracks down on crypto platforms in an effort to stymie the criminals who do use it for nefarious purposes?

"There's definitely a slant to that question with the 'finally cracking down' line. Criminals commit crimes. They've been doing it for a long time before crypto. [A very low, single-digit percentage of crypto transactions are used] for crimes. Remember Bitcoin has a permanent paper trail of every transaction that's ever happened. It's published publicly every ten minutes. That is a terrible feature for committing crimes."

"Much more crime happens with cash or through regular banks...If governments today had to approve either Bitcoin or cash, there's no chance they would approve cash. Cash is mega-sketchy. Crypto is much better."

Q. Would you call this a buying opportunity, this Elon Musk tweet, the finance investigation?

"I would. Bitcoin's still well below its ten-year compound annual growth trend. It's not like we're in overpriced territory or it's a bubble. All these major firms and the Wall Street wealth platforms have now allowed their clients to buy Bitcoin. Big corporations, many of whom are not called Tesla Motors or Elon Musk, are buying Bitcoin. Those trends are just starting and this is a multi-decade disruption. I think we have a long way to go here."