

Luxor ▲

Brother Can You Spare a Dime? **A Bear Ate Mine**

Hashrate Index 2022 Year In Review

Authored by: Colin Harper, Jaran Mellerud, Balmy Investor,
Ben Harper, Ethan Vera, Jon Conley, Nick Hansen

Designed by: Mikołaj Gałęziowski

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Executive Summary: Gold Turns to Rust

Executive Summary

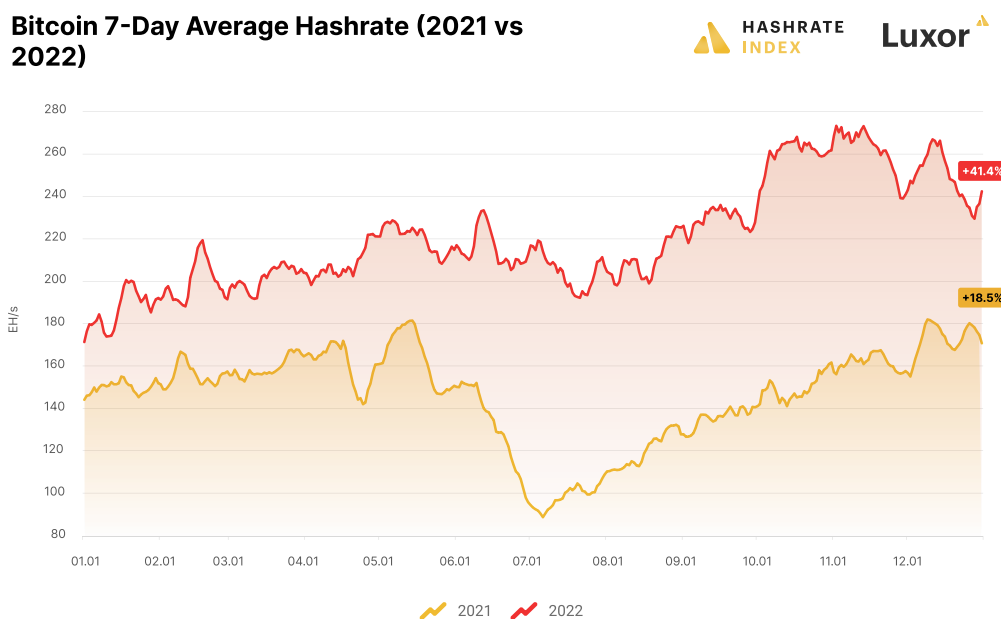
2022 was the year that gold turned to rust.

The year began with Bitcoin's continued sell-off from its \$69,000 all-time high. It ended with multiple industry stalwarts ensnared in bankruptcy proceedings (and many more in limbo) and Bitcoin's price below its 2017 bull market all-time high. As prices across the board started slipping, the first catalyst in a still-spreading contagion event was Luna's collapse. At the time, we didn't know how much this would affect the Bitcoin mining sector, but it was the ripple that precipitated a tsunami. Seemingly rock-solid institutions were shaken one-by-one: Three Arrows Capital (3AC) fell first, followed by Celsius, BlockFi, Voyager, Babel, Vault, and FTX. Others like DCG, Binance, and Gemini saw significant and potentially irreparable damage.

Miners haven't been spared from the culling. The leverage that snaked its way into the mining sector started unwinding as hashprice reached all-time lows; Compute North and Core Scientific filed for Chapter 11 bankruptcy, while Argo, Blockstream, Iris, Greenidge, and many others went through major restructurings.

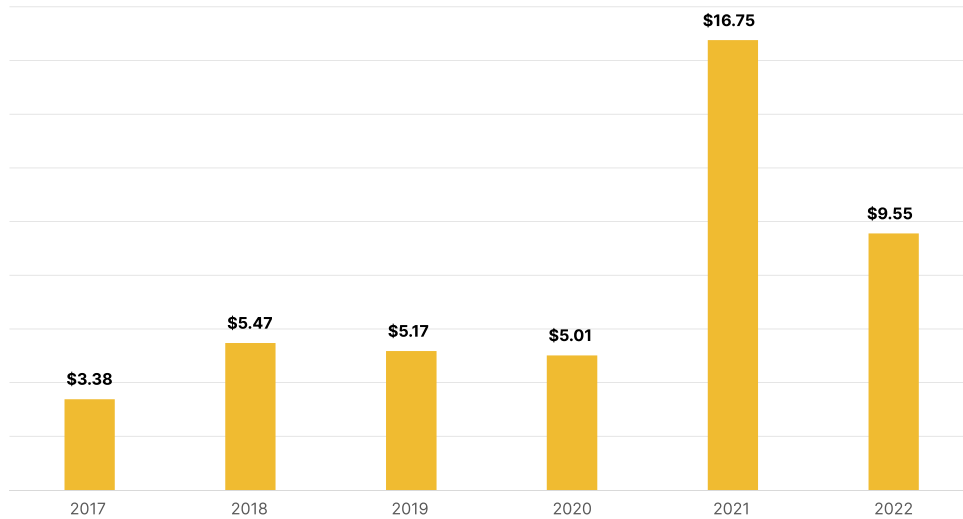
Adding to the credit contagion, Bitcoin's bear market, rising hashrate, and bullish energy prices have conspired to crush mining margins. Hashprice is exiting the year at all-time lows, ASIC prices are down over 85%, and the mining sector is facing its own wave of bankruptcies.

Even so, Bitcoin's hashrate grew 41% in 2022 (compared to 2021's 18% growth) as if to spite the year's market carnage. That said, China's Bitcoin mining ban greatly stunted hashrate growth in 2021, and Bitcoin's hashrate started to taper downward toward the end of 2022 as the hashprice lows knocked off run-of-the-mill and high-cost operators – not to mention a continental blizzard in the US that put mining farms on the fritz.



With Bitcoin's price impaired, miners made significantly less on a USD-basis compared to 2021. Still, the \$9.55 billion in revenue is still nearly double the rewards miners reaped each year in 2020, 2019, and 2018.

Yearly BTC Miner Rewards (in BLN USD)



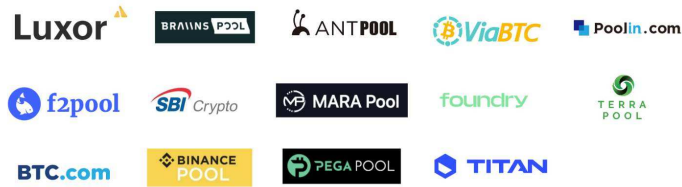
Source: Hashrate Index, Coin Metrics

Despite the down market, the Bitcoin mining ecosystem continues to expand, with more companies offering differing products and services up-and-down the Bitcoin mining stack. It's probable that this landscape shrinks and consolidates over 2023, as Bitcoin miners approach what could be the most hostile market environment ever.

To be sure, 2023 is ramping up to be a brutal year for Bitcoin miners, especially if the bottom isn't in for Bitcoin. Miners will need to cut costs where possible, pare down debt, and fatten their liquid cash positions to make it through the remainder of the bear market. 2022's budding trend of bankruptcies and acquisitions will likely come in full bloom in 2023.

For the coming year, the mantra is simple: survive.

Mining Pools



ASIC Manufacturers



Colocation/Hosting Providers



Foundries



Miners



ASIC Brokerage



Container Providers



Research



ASIC Financing



Custom Firmware



Mining Software



2

Hashprice hits all-time low

2022

USD Hashprice

2021

Low:

\$55.94/PH/day
(November 22)

\$191.94/PH/day
(May 29)

Average:

\$123.88/PH/day

\$314.61/PH/day

High:

\$246.86/PH/day
(January 1)

\$412.57/PH/day
(October 20)

BTC Hashprice

Low:

0.003450 BTC/PH/day
(October 24)

0.005262 BTC/PH/day
(December 27)

Average:

0.004264 BTC/PH/day

0.006740 BTC/PH/day

High:

0.005280 BTC/PH/day
(January 6)

0.009352 BTC/PH/day
(July 19)

2022 was like 2021 in reverse, and for miners, no dataset illustrates this better than hashprice.

2021's bull market – and the hashrate blackout caused by China's Bitcoin mining ban – made the year an extremely profitable time to mine Bitcoin. **The average hashprice for 2021 was \$314.61/PH/day and the yearly high was \$412.57/PH/day.**

2022 was just the opposite.

The USD hashprice high for 2022 of \$246.86/PH/day came on January 1, and it was only downhill from there. The average USD hashprice was \$123.88/PH/day, and the \$55.94/PH/day low for the year was also an all-time low for Bitcoin's hashprice. Rises in power costs, which we cover in our chapter on energy, put additional pressure on mining margins.

USD Hashprice 2022 vs 2021

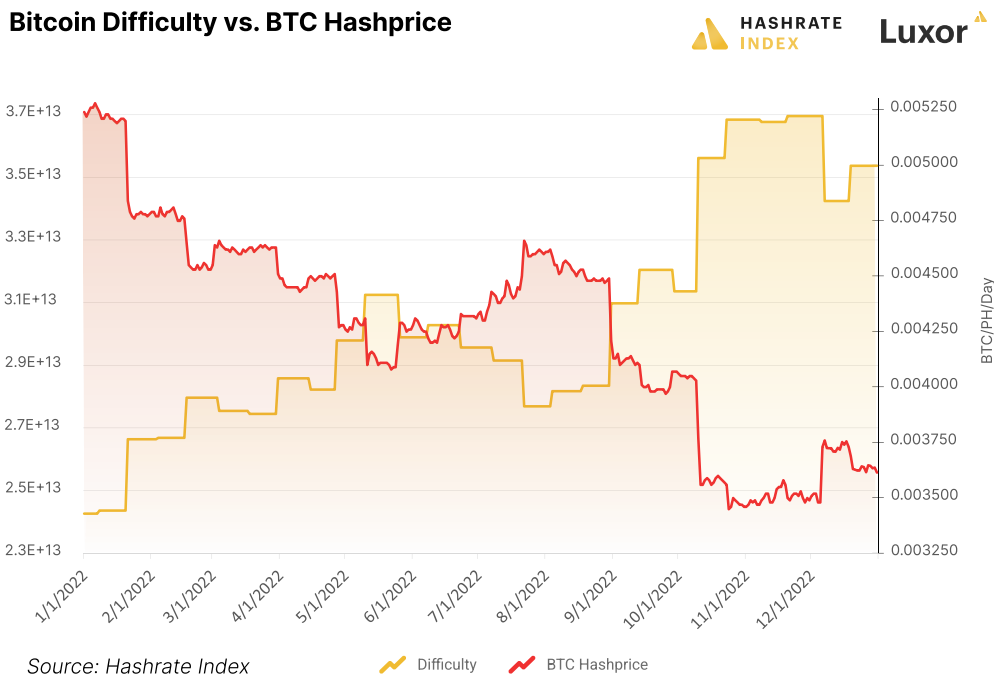


Source: Hashrate Index

Miners continued to deploy hashrate throughout the year against the downward trend in hashprice, and difficulty rose accordingly, further depressing hashprice. The only relief came in the late spring and summer with Bitcoin's selloff from \$30,000 to \$20,000. Some unprofitable miners dropped off the network at that time, while a series of heatwaves in North America choked out more hashrate still.

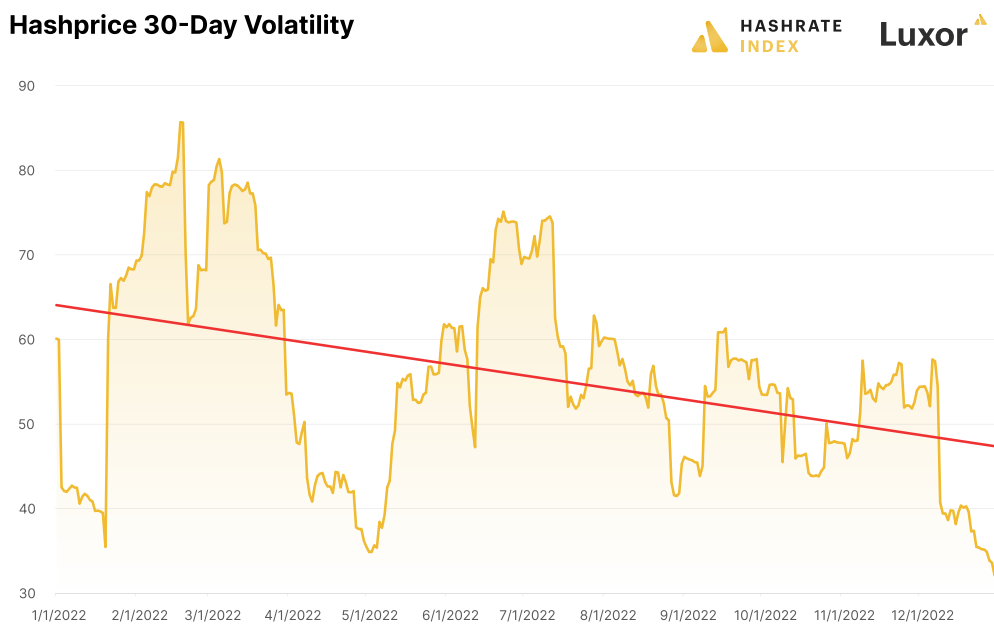
When Bitcoin's price took a dive in May following the collapse of TerraUSD (Luna), hashprice fell accordingly, and miners with higher electricity costs wound down their hashrate as a result. The summer's series of heatwaves were more impactful though, causing miners in heat-throttled areas to power down to avoid overheating their machines. The blistering temperatures stressed some grids to max capacity as AC use surged; Texas – the most hashrate dense state in the US – is the prime example. (Miners played a prime role in balancing grids in states like Texas, but more on that in the next chapter).

Over the summer, Bitcoin's hashrate fell from a peak of 233 EH/s to a low of 192 EH/s, a 17.6% drawdown. The drawdown gave hashprice a brief boost that was quickly neutralized by a 9.26% positive difficulty adjustment on August 31. Besides the summer's reprieve, the general trend for difficulty in 2022 was up only.



Freezing temperatures in December also contributed to grid stress and miner load shedding. Many miners across North America had to curtail their power draw to free up energy for the rest of the grid during both the summer heatwaves and December cold snaps.

All of that said, hashprice volatility eased as the year progressed. Unlike 2021, where hashrate restructuring from China's mining ban was a major driver of hashprice volatility, the majority of volatility in 2022 stemmed from Bitcoin's price movements, which were less severe in the second half of the year.

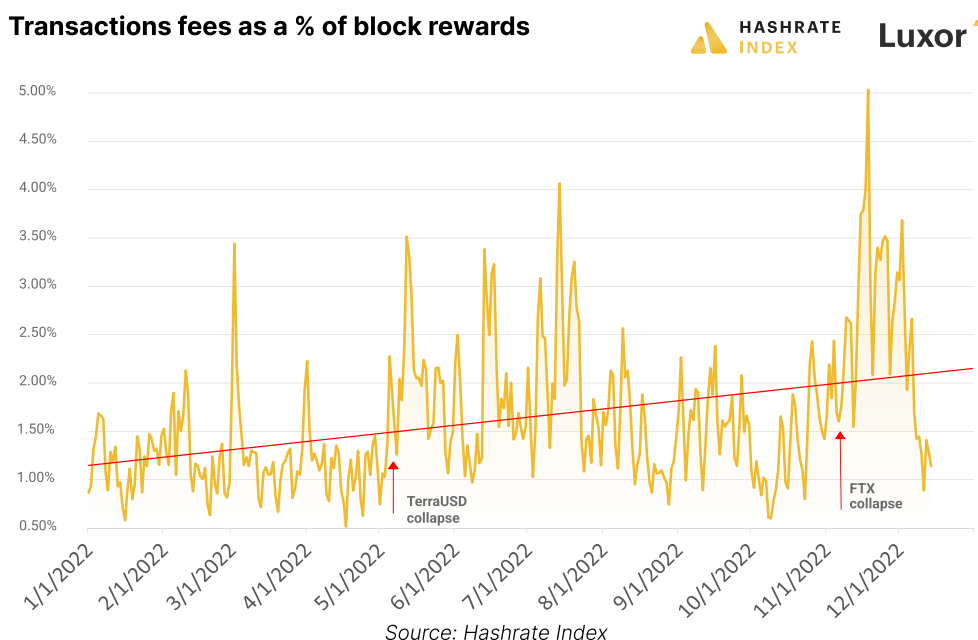


2.1 Price capitulation drives bitcoin transaction fees

Transaction fees made up a substantially smaller portion of Bitcoin mining rewards in 2022 when compared to basically any other year in Bitcoin's teenage lifespan.

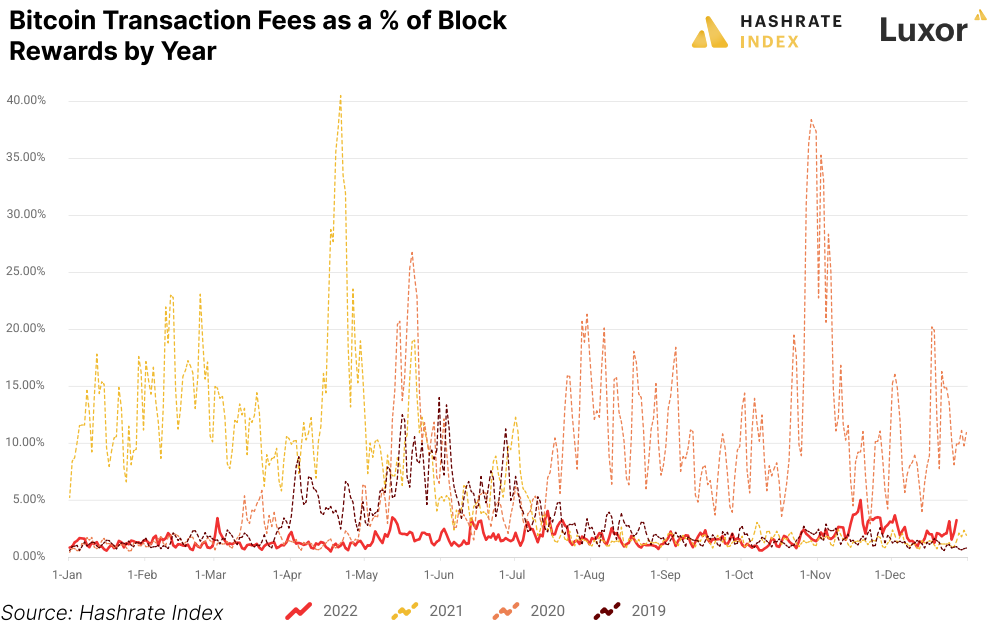
Transaction fees made up 6.7% of block rewards on average in 2021, while they only made up 1.6% of block rewards on average in 2022. Even if we take the average for blocks that were mined in the second half of 2021 after China's mining ban, 2021's average is still higher at 1.8%.

Bear markets generally entail less economic activity on-chain, so the downtick in fee revenue isn't that surprising. However, we found that higher fee activity usually occurred during extreme drawdowns in Bitcoin's price that precipitated from collapses of core market infrastructure. As the chart below illustrates, transaction fees spiked in the aftermath of TerraUSD's and FTX's collapses, events which both led to new yearly lows for Bitcoin's price.



2022 was the quietest year for transaction fee revenue in the last 4 years. Analysts often point to scaling solutions like Segwit for Bitcoin's base layer, in addition to second layer solutions like the Lightning Network, when explaining the decline in transaction fee revenue. But these developments only explain the decline so much, especially considering the decline becomes more precipitous following China's Bitcoin mining ban. (One plausible explanation for why fees are much higher in a pre-China mining ban era: a result of Chinese miners and pools flooding Bitcoin's mempools with transactions to drive fees higher). That said, we can't rule out Segwit adoption completely when explaining lower fee volumes, as it no doubt is playing some role.

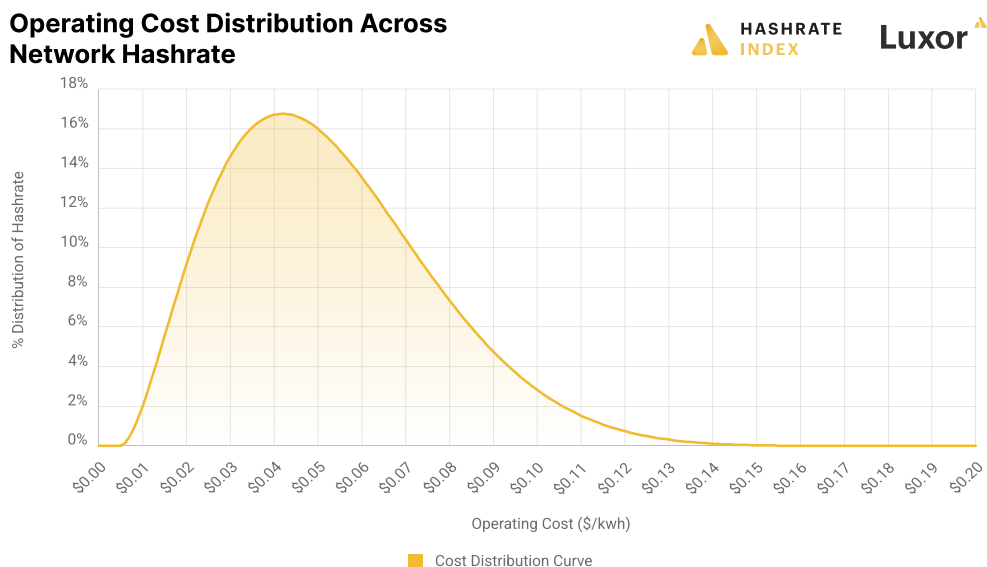
We can see in the chart below that transaction fees ramp up in the latter half of 2020 as Bitcoin enters the bull market. Fees surged in 2021, only to drop off after China's mining ban went into full effect to the negligible levels we still experience today. Relatively small as they may be, transaction fees progressively increased throughout 2022.



2.2 Hashprice resistance levels

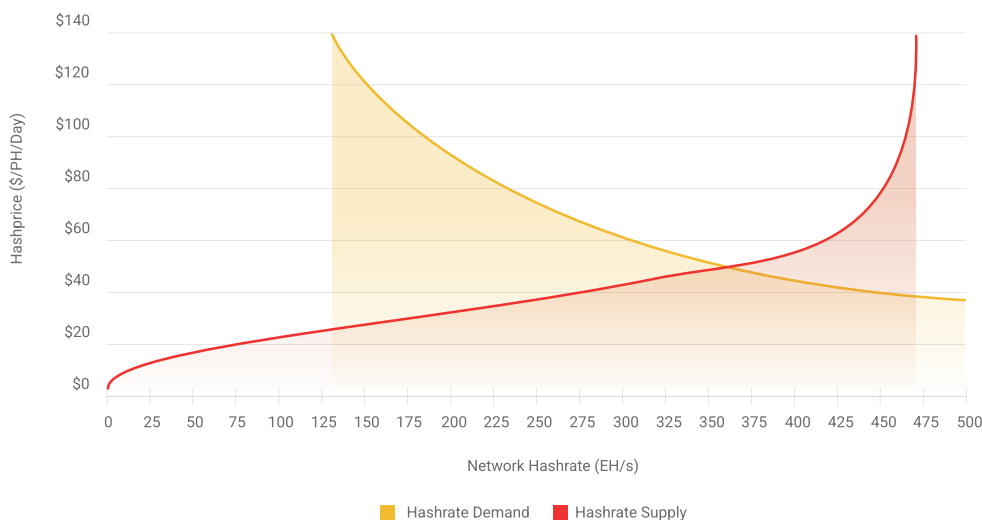
As Bitcoin's bear market and hashrate growth conspire to crush hashprice, more and more miners are butting up against breakeven prices – and if they're not there yet, they're getting close.

With an end-of-year hashprice of \$60/PH/day, miners with new-gen machines (like the S19j Pro) and power costs at \$0.082/kWh and above are no longer profitable. We estimate that roughly 41% of network hashrate is produced within an all-in operational cost range of \$0.06-0.09/kWh (hosting costs included). As such, a not-insignificant portion of the network is likely closing in on breakeven/unprofitability levels, which raises the question: just how much room does Bitcoin's hashrate have to grow next year?



The answer: if hashprice keeps falling, not much. Using our [hashprice resistance model](#), we can estimate a theoretical ceiling for Bitcoin’s hashrate in 2023 based on the supply and demand of hashrate set by Bitcoin’s hashprice. Given the equilibrium displayed in the chart below (the point at which the supply and demand curves intersect), Bitcoin’s hashrate could reasonably increase to 350 EH/s next year *so long as* hashprice remains at or above \$50/PH/day. That said, we should approach this model with caution. It is a mathematical representation to further our understanding of mining economics and compare directional outcomes under various assumptions – not a completely accurate detailed mapping of the entire Bitcoin mining economy, or a forecast for the future.

Equilibrium with 2023 Supply Curve



2.3 Luxor’s Hashprice NDF gives miners a native hedging instrument

In 2022, the importance of risk management for Bitcoin miners became painfully evident. In general, Bitcoin mining is a low-margin commodity business that is highly competitive, except during bull market peaks. Therefore, protecting cash flows is crucial for the long-term success of a mining operation.

Until recently, miners only had access to Bitcoin futures and a small patchwork of physically-settled, short term-duration hashrate forward options, and they were unable to properly hedge price risk to the commodity they produce – hashrate. These limited hedging options left many miners exposed to significant hashprice risk and made it difficult to build defensible businesses in a highly cyclical industry.

In late 2022, [Luxor introduced](#) the [Hashprice Non-Deliverable Forward \(NDF\) contract](#), which allows miners to buy or sell future hashrate and "lock-in" a specific hashprice to provide a hedge for their cash flows.

Luxor’s Hashprice NDF brings together buyers and sellers of hashrate for standardized and customizable non-deliverable hashprice forwards. After completing the appropriate onboarding documentation, the buyer and seller of a Luxor NDF contract simply agree to the following:

- Unit Hashprice – USD (e.g., \$65.00 per PH/s/Day), or BTC (e.g., 0.00362 BTC per PH/s/Day).
- Daily Hashrate – Minimum 1 PH (e.g., 30 PH/s).
- Duration – 1-Month, 2-Month, 3-Month, and Customizable (e.g., 90 days).

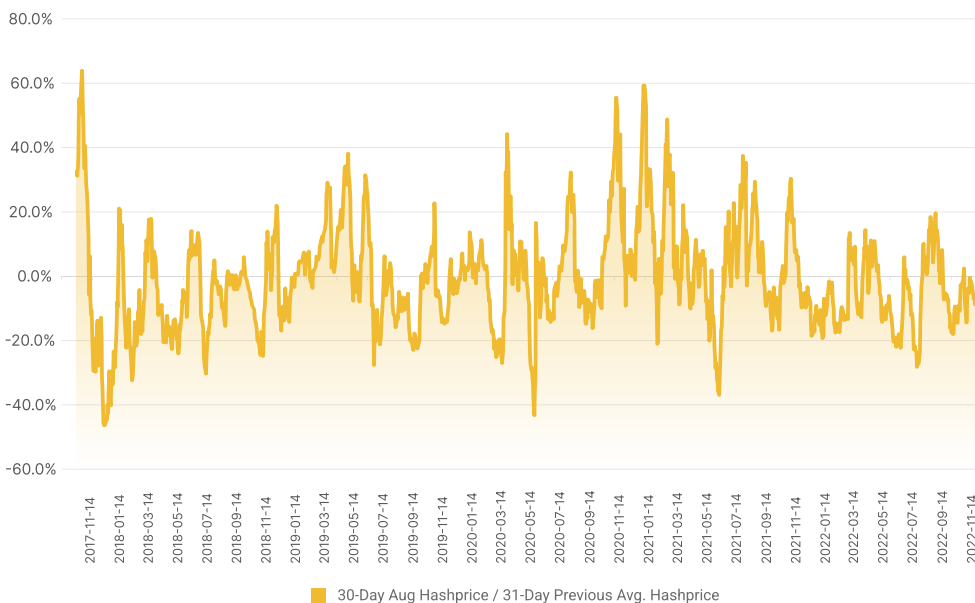
For all market participants, historical performance and NDF contract outcomes are top of mind. Unfortunately, with only a couple months passed since the NDF launch, there isn't enough data to properly evaluate the contract over an extended period of time. For this reason, to give market participants a true gauge of NDF behavior, we turn to historical data and evaluate what would have happened before the NDF launched, not just what did happen over the last few months.

For robust data on historical NDF performance, we evaluated 30, 60, 90, 120 and 180-day contracts over the past five year period (up to November 14, 2022). For each contract duration, and for each day in the period, we evaluated how a hypothetical contract would have settled relative to the average hashprice one-day prior to the trade.

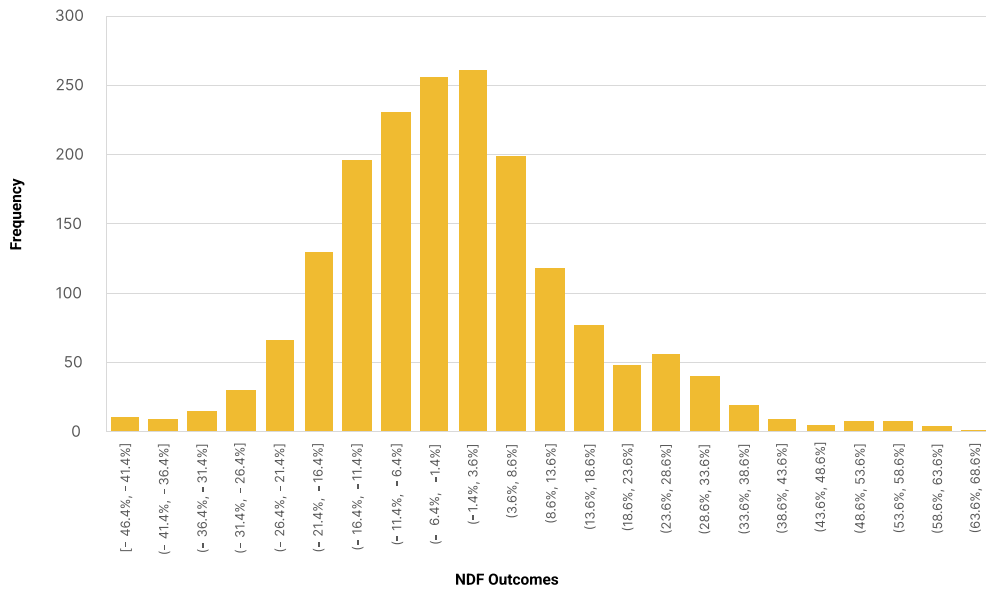
The next two charts show the outcomes from hypothetical 30-day contracts over the last five years. The first shows the performance across time and the second shows the frequency of different outcomes in a histogram. These charts show how 30-day NDF contracts would have settled every day over the last five years relative to hashprice 31 days prior.

When the number is positive, the seller would have paid the difference to the buyer, and when the number is negative, the buyer would have paid the difference to the seller. The performance of the contract is shown below on a percentage basis – actual payouts would have been proportional to the size of the contract (i.e., daily hashrate under contract).

30-Day Contract Performance, Last 5 Years



30-Day Contract Performance, Last 5 Years



The table below summarizes the data for 30-day contracts and also includes summary statistics for 60, 90, 120, and 180-day NDFs. The first column indicates the contract duration being analyzed. The next four columns show the mean, standard deviation, maximum and minimum outcomes for each contract duration over the five year period. The final two columns show confidence intervals, assuming a normal distribution with observed mean and standard deviation over the last five years.

x-Day Avg. Hashprice / Hashprice (x+1)-Day Previous, Last Five Years						
Contract Duration (x)	Mean	Standard Deviation	Max	Min	+/- 90% Confidence	+/- 99% Confidence
30	-1%	16%	64%	-46%	26%	41%
60	-2%	22%	75%	-58%	35%	56%
90	-3%	29%	114%	-65%	45%	72%
120	-2%	36%	147%	-69%	56%	90%
180	-1%	49%	221%	-75%	80%	127%

There are a number of takeaways from this analysis. In particular:

- We observe, on average, a negative trend in hashprice. This is due primarily to increases in network difficulty responding to increases in network hashrate.
- The volatility of Luxor’s Hashprice NDF increases with duration. This can be observed in the standard deviation, maximum, minimum, and confidence interval columns which are strictly increasing on an absolute basis with duration.

- For all contract durations, the observed maximum outcome is higher on an absolute basis than the observed minimum outcome over the past five years. This is often the case in other derivative markets. Since prices can only fall 100%, buy-side losses are bounded by 100% of the contract value. Sell-side losses on the other hand are unbounded – prices can rise more than 100% and have done so in hashrate markets over the last five years.
- The averaging methodology used to settle Luxor’s Hashprice NDF reduces volatility relative to the methodology used for forward contracts of discrete commodities. This means Luxor’s Hashprice NDF is not only a better hedging instrument than existing Bitcoin futures from a revenue correlation perspective, but it also has the potential to offer miner’s access to hedging products with lower upfront collateral requirements. This is particularly relevant at a time when Bitcoin mining economics are poor and miners are strapped for capital.



3

Bitcoin might be in a bear market, but energy isn't

A perfect storm of unfortunate developments hit the bitcoin mining industry this year. Simultaneously as hashprice went down in flames and evaporated mining revenues, many miners saw their electricity prices rise as the world grappled with an energy crisis. The sudden electricity price inflation was an unpleasant surprise for most miners after several years of stable (and even downward-sloping) electricity prices.

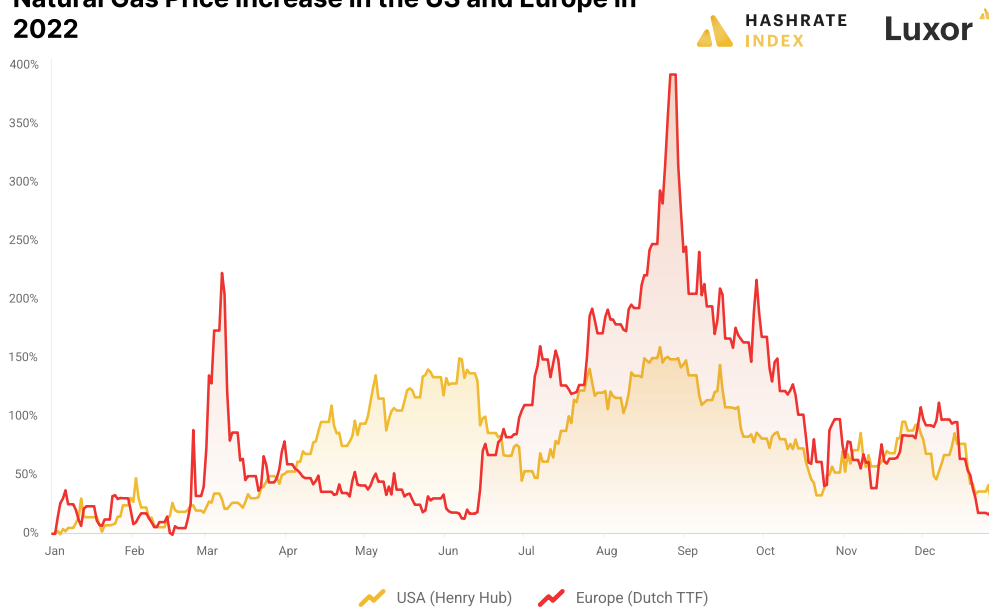
In this chapter, we examine the causes of the electricity price inflation and reveal which US states were the most and least impacted. We also discuss the implications for bitcoin mining economics and show how hosting rates were affected.

3.1 Geopolitical turmoil in Europe sparked a global energy crisis

A severe natural gas supply and demand imbalance is perhaps the leading cause of the global energy crisis and the resulting electricity price inflation. Natural gas is the lifeblood of most electricity markets. As the most flexible primary energy source, natural gas is an exceptionally suitable fuel for peaker plants (power plants that adjust generation to accommodate spikes in electricity demand). Since natural gas-powered plants are often the last to be dispatched, they usually set the market price for electricity according to the merit-order effect.

Europe has historically relied on Russia for more than 40% of its natural gas needs, so Russia's invasion of Ukraine in February 2022 exposed the fragile state of Europe's energy security. As the Russian tanks rolled into Ukraine, the price of the Dutch TTF – a European trading point for natural gas – surged by more than 200% in a few weeks. Prices then normalized for a few months but exploded even higher during the summer, peaking at a 400% increase from the beginning of the year.

Natural Gas Price Increase in the US and Europe in 2022



Source: TradingView

While Europe has little domestic fuel production and highly depends on natural gas imports, North America has much better energy security thanks to domestic production of oil and gas. Still, as Europe desperately attempts to break free from its addiction to Russian natural gas, it has started using North American liquefied natural gas (LNG) as a replacement. As energy-deprived Europeans bid up the price of North American natural gas, energy price inflation quickly spread across the pond to the US and Canada. However, natural gas prices are still significantly lower in North America than in Europe due to the difficulties of processing and transporting LNG.

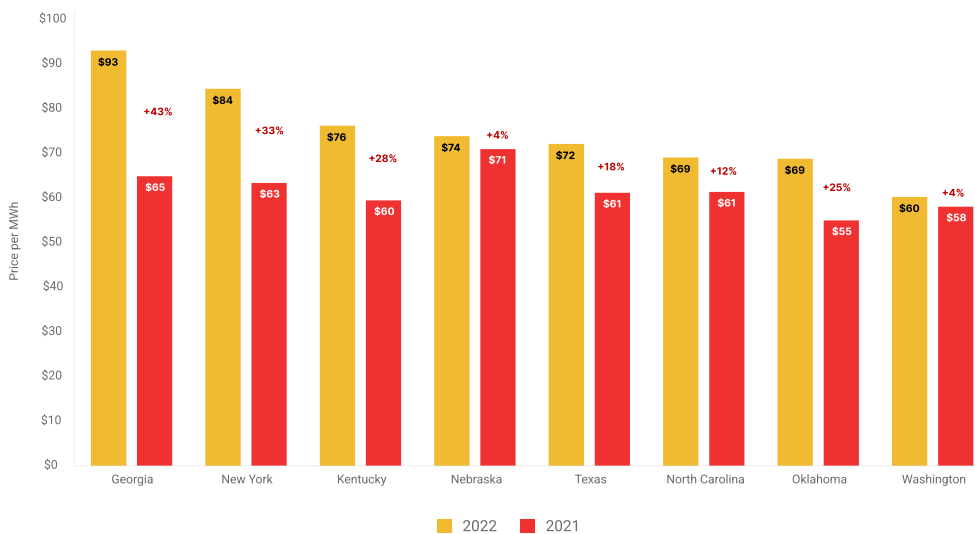
Natural gas in the US (Henry Hub) is currently trading at \$3.9, much, much lower than its \$71 price point in Europe (Dutch TTF).

As we already explained, natural gas is the most vital fuel in most electricity systems, meaning that a rising price in most cases causes electricity prices to increase as well. This year electricity prices have exploded in most markets globally, particularly in Europe. The continent’s bitcoin mining industry is now cornered into remote and electrically self-sufficient places like northern Norway, northern Sweden, and Iceland. Still, as explained in the following section, North American miners also saw substantial electricity price increases in 2022.

3.2 Energy price inflation grips North America

While Europe is the starting point and center of this energy crisis, the crisis crept into North America as well. The chart below compares the 2022 and 2021 average industrial electricity prices in some of the most popular US bitcoin mining states. In most of these states, industrial consumers saw their electricity rates increase by double-digit percentage points between 2021 and 2022.

Average Industrial Electricity Price by US State in 2022 vs 2021

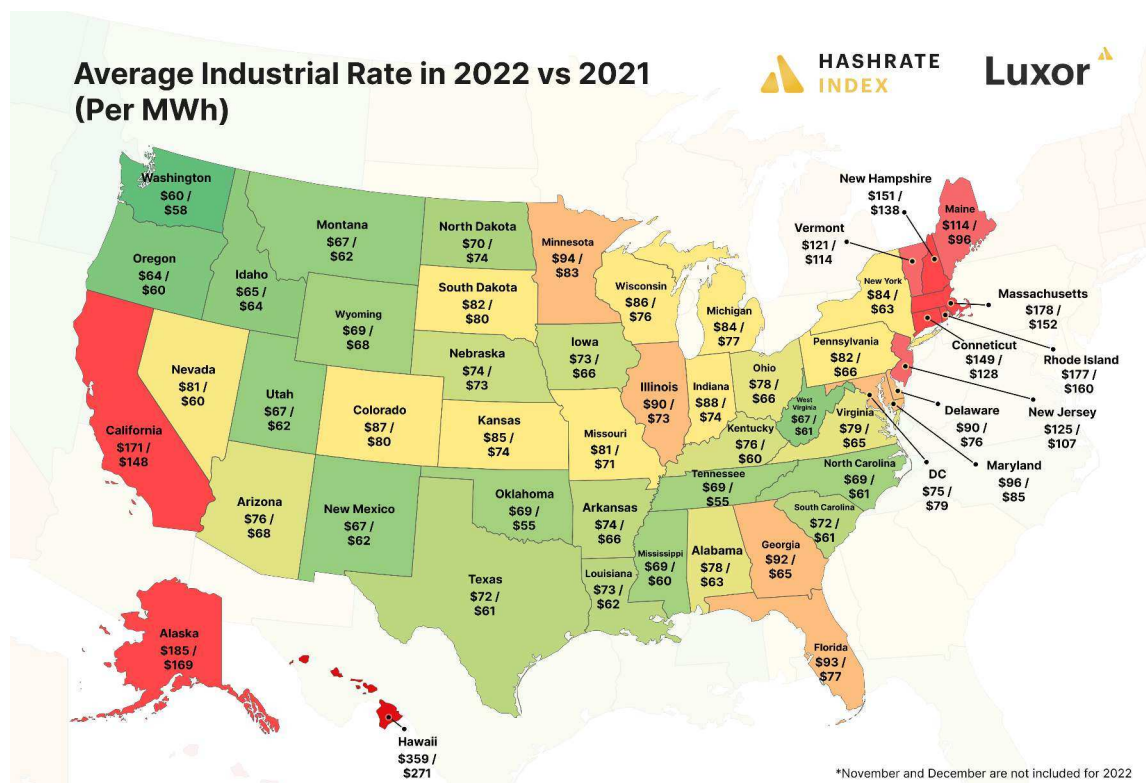


Source: EIA.gov

Interestingly, Georgia – one of the most popular bitcoin mining states – saw the most significant price increase, with the average industrial electricity price surging by 43% from \$65 to \$92 per MWh between 2021 and 2022. Since the S19 Pro’s revenue per MWh is \$92, most miners in this state should currently operate close to cash flow break-even. The rise in power prices in Georgia was likely a significant contributor to Core Scientific’s bankruptcy.

Texas, the home of the mega mines, has also seen its average industrial electricity price increase substantially in 2022 from \$61 to \$72 per MWh. This wind and solar rich state saw a massive flux of mining capacity build out in 2021, but a considerable share of these projects are struggling under the current hashprice and electricity price environment. Argo is one example, which recently sold its newly built flagship facility to Galaxy Digital.

Meanwhile, Washington only saw a 4% increase in the average industrial electricity price from 2021 to 2022. As we explain in the next section, the state’s abundant supply of stranded hydropower and low reliance on natural gas could explain its low electricity price inflation.



Source: EIA

Indeed, Washington has the cheapest industrial electricity in 2022. With an average price per MWh of \$60, the hydro-powered state has slightly cheaper industrial electricity than its neighbor Oregon (\$64 per MWh). Idaho, West Virginia, and Utah are also among the states with the cheapest electricity in the US (Idaho runs primarily on hydro, while Utah and West Virginia rely primarily on coal).

The average industrial electricity price in the US in 2022 was \$85 per MWh, a 16% increase from 2021. Even after this electricity price inflation, 35 states have lower average industrial electricity rates than the S19 Pro's current break-even electricity price of \$92 per MWh.

Bitcoin mining is still very viable in many US states, particularly considering the opportunities for miners to reduce their ultimate electricity prices by engaging in sophisticated power strategies. These power strategies can take many forms, but a common theme is that miners exploit the unique low-consequence interruptibility of the bitcoin mining process by adjusting their electricity consumption based on market signals. (Other high-energy intensive industries, like traditional data centers or industrial manufacturing, cannot power down without disrupting major economic activities).

Riot Platforms is a good example of the flexibility Bitcoin mining can bring to electricity grids. The public miner drastically reduced its ultimate electricity rate in 2022 by curtailing electricity usage during the summer to earn power credits. The drawback of the strategy is reduced up-time, which is evidenced by Riot only having an implied up-time of 52% in July. Still, the company's significantly reduced electricity costs make their periodic curtailments well worth it.

We will likely see miners increasingly sacrificing up-time to achieve lower power prices. In December, Bitcoin's hashrate dropped significantly from some combination of freezing weather (which caused operational issues) and miners shutting off in response to high electricity prices caused by this cold weather.

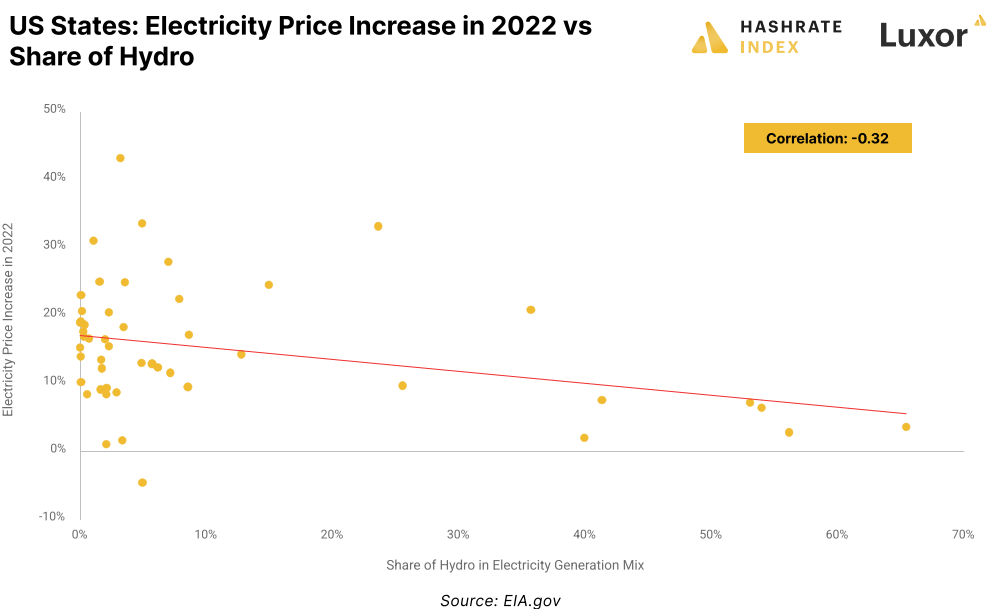
Riot July 2022 Operations	BTC/BTC Equivalent	\$ Value
BTC Mining	318	\$6,900,000
Power Credits	439	\$9,500,000
Total	759	\$16,400,000
Riot August 2022 Operations	BTC/BTC Equivalent	\$ Value
BTC Mining	374	\$8,300,000
Power Credits	136	\$3,000,000
Total	510	\$11,300,000
Riot December 2022 Operations	BTC/BTC Equivalent	\$ Value
BTC Mining	659	\$11,200,000
Power Credit	290	\$4,900,000
Total	949	\$16,100,000

Source: Riot production updates

3.3 Not all energy is generated equally

As we explained at the beginning of this section, electricity systems need flexible primary energy sources to meet marginal demand. Like natural gas, hydro is a relatively flexible primary energy source, as power plant operators can easily adjust the electricity production of hydropower plants by changing the volume of water flowing through the turbines (low water levels and droughts complicate this process, of course). Due to this flexibility, geographic regions blessed with hydropower generally don't require natural gas peaker plants.

In some lucky states, their abundant hydropower and independence from increasingly expensive natural gas has shielded them from the worst electricity price rises. The chart below shows the relationship between states' shares of hydropower and the changes in their industrial electricity prices in 2022. The inverse correlation of -0.32 signals that the hydro-rich states have seen a significantly lower increase in their electricity prices in 2022 than those with little hydro.

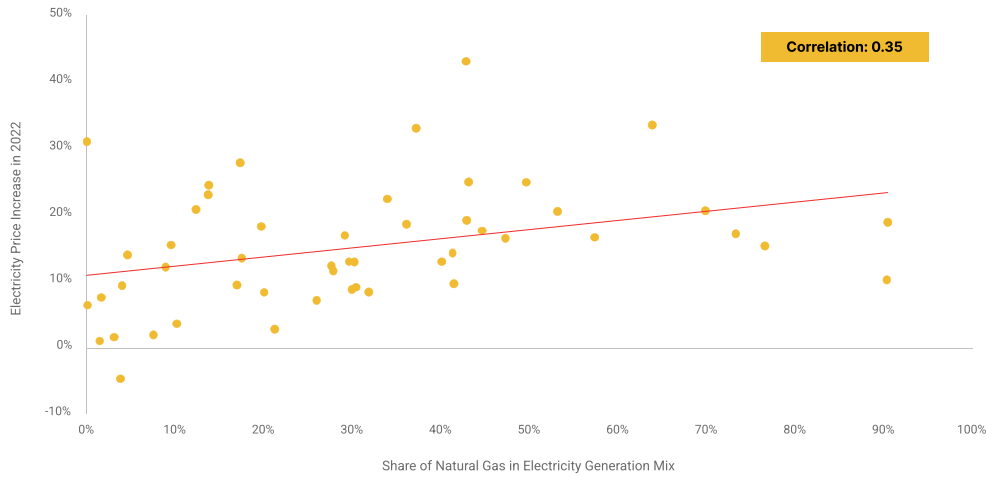


No state powered by more than 40% hydro has seen its average industrial electricity price increase by more than 8% in 2022. Hydro-rich states like Washington, Oregon, Idaho, and Montana haven't seen substantial increases in their electricity prices, and miners there can still access relatively cheap electricity.

The important caveat here is that the hydro will only be cheap if it's stranded or localized. If sufficient transmission capacity exists to transport the excess hydropower to a more expensive electricity market where natural gas is a price setter, customers in the expensive area will bid up the price of the hydropower. Many hydro-miners in the Nordic countries in Europe suffered from this experience in 2022, which we describe in detail in chapter 9. Additionally, water shortages and droughts can severely hamper hydro production, as we saw in Europe last summer.

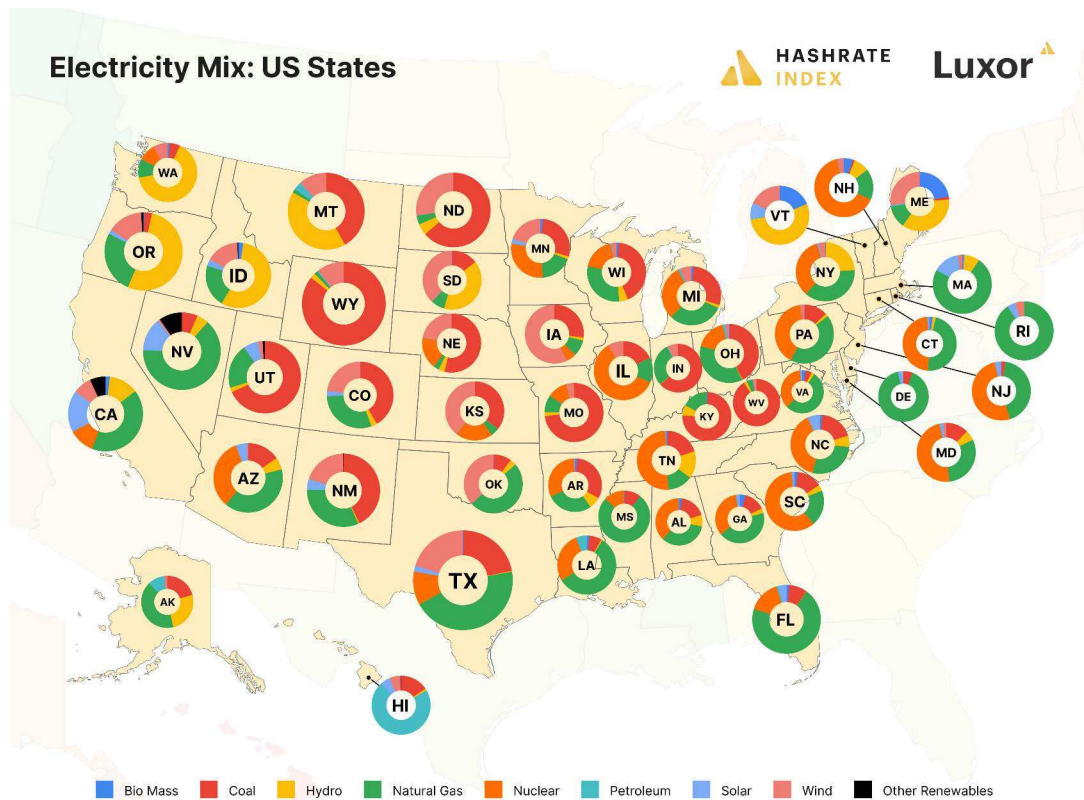
We have already found that stranded hydropower gives miners in states like Washington certain protection from electricity price inflation. This phenomenon works the opposite way in states with a high share of natural gas. As shown in the chart below, the correlation between states' share of natural gas and their electricity price changes in 2022 is 0.35, indicating a relatively strong relationship.

US States: Electricity Price Increase in 2022 vs Share of Natural Gas



Source: EIA.gov

The map below shows the electricity generation mix of all US states. As you can see, the states where electricity is the cheapest - Washington, Oregon, Idaho, West Virginia, and Utah - all have relatively low shares of natural gas in the electricity generation mix. The states with the lowest power rates in 2022 were predominantly powered by either hydro or coal.



Many miners have learned a painful but important lesson in 2022: that securing a low, long-term electricity price is a vital component of the mining business. Miners can achieve that by signing a long-term physical or financial hedge or getting access to stranded energy uncorrelated with global fuel prices. But as we will explain in the next section, hedging electricity costs is often easier said than done.

3.4 The barriers to hedging electricity costs

Even though hedging electricity costs can be critical, it's far from a simple process. This section will discuss several reasons why many bitcoin miners didn't lock in long-term low electricity rates while they still could.

Firstly, many miners were reluctant to lock in electricity prices that they believed would keep falling. Electricity had been in a deflationary cycle for several years prior to 2022, and the market anticipated that prices would keep decreasing based on negative future power curves in late 2021. Many miners bet on power prices to keep declining and were caught on the wrong side of the trade when prices increased instead.

There are also financial barriers to hedging electricity costs. Hedging requires a lot of collateral, which can significantly reduce project returns given the high cost of capital in the bitcoin mining industry.

Miners can hedge through a fixed-price power purchase agreement (PPA) or an electricity derivatives contract. For a PPA, the margin requirement is usually 3% to 5% of the notional value of the trade. For example, a contract worth \$100 million will require collateral of between \$3 million and \$5 million. The margin requirements for an electricity derivatives contract are bigger and usually start at 20% of the notional value, giving the \$100 million contract a margin requirement of \$20 million.

Deposits of this magnitude increase the capital requirements of mining operations. With the cost of capital high in the mining industry, many miners would rather spend this money to expand hashrate rather than front it as collateral for power contracts.

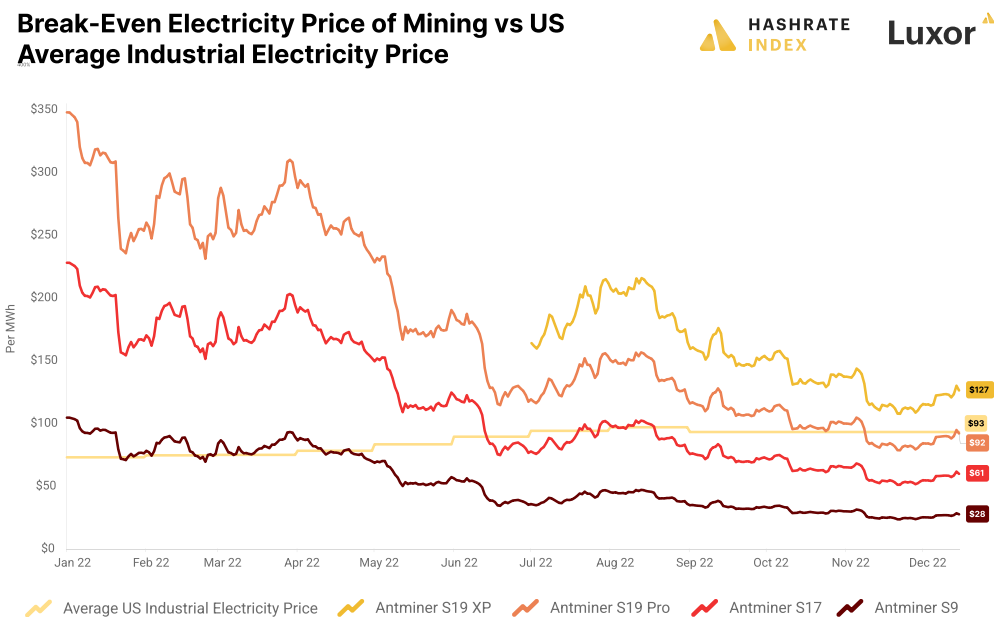
After seeing the vastly negative impact rising electricity prices had on their businesses in 2022, miners now have a newfound interest in hedging power contracts. Many are undoubtedly planning to hedge electricity costs when prices come down again, and we expect hedging to be one of the big themes of 2023.

3.5 Breakeven thresholds loom

As we discussed in chapter 2, a shrinking bitcoin price and swelling hashrate pushed hashprice to all-time lows this year. In the current depressed revenue environment, only miners with access to exceptionally cheap electricity can run at a significant profit. The problem, as ever, is that cheap electricity is getting harder to come by as prices in most markets have risen substantially in 2022.

The chart below shows the break-even electricity price of mining with different machines, compared with the average industrial electricity price in the US. **We see that, after increasing significantly in 2022, the average US industrial electricity price of \$93 per MWh is now above the S19 Pro's \$92 revenue per MWh.** While most US miners have access to cheaper electricity than the average industrial rate, there are plenty of miners barely breaking even right now.

The chart also illustrates just how obsolete the S9 is under current conditions, and how the S17 and similar hardware are quickly becoming obsolete, as well.



Source: Hashrate Index, EIA.gov

The current depressed state of mining economics appears even worse when we compare it to the market environment of late 2021. At that time, with hashprice inflated and much lower electricity prices, even running an S9 at the average US industrial electricity price was extremely profitable. This ancient machine produced a revenue of \$175 per MWh, a number that has now shrunk to \$28 per MWh.

Only miners operating the latest generation machines are cash flow positive at the average US industrial electricity price. **The S19 XP has a revenue per MWh of \$127, corresponding to an acceptable gross margin of 37% at an electricity price of \$93 per MWh.** Given their superior energy efficiency and the impaired state of mining margins, these machines command a significant premium in the ASIC market (more on that in chapter 4).

The following table showcases breakeven costs at various power levels for different mining hardware. It is color coded according to a \$60/PH/day hashprice.

Electricity Price (\$/kWh)	Hashprice (\$/PH/day) breakeven S9	Hashprice breakeven S17	Hashprice breakeven S19j Pro	Hashprice breakeven S19 XP
\$0.01	\$24	\$11	\$7	\$4
\$0.02	\$48	\$21	\$15	\$7
\$0.03	\$72	\$32	\$22	\$11
\$0.04	\$96	\$43	\$29	\$15
\$0.05	\$120	\$54	\$37	\$18
\$0.06	\$144	\$64	\$44	\$22
\$0.07	\$168	\$75	\$51	\$26
\$0.08	\$192	\$86	\$59	\$29
\$0.09	\$216	\$96	\$66	\$33
\$0.10	\$240	\$107	\$73	\$37

Based on a hashprice of \$60/TH/day | Source: Hashrate Index

It's important to note that even though electricity prices have risen considerably in most regions globally, most miners still have access to significantly cheaper electricity than the average US industrial electricity rate of \$93 per MWh. The average all-in electricity price in the industry may have been closer to \$40 per MWh one year ago but has likely crawled up toward \$50-60 per MWh now.

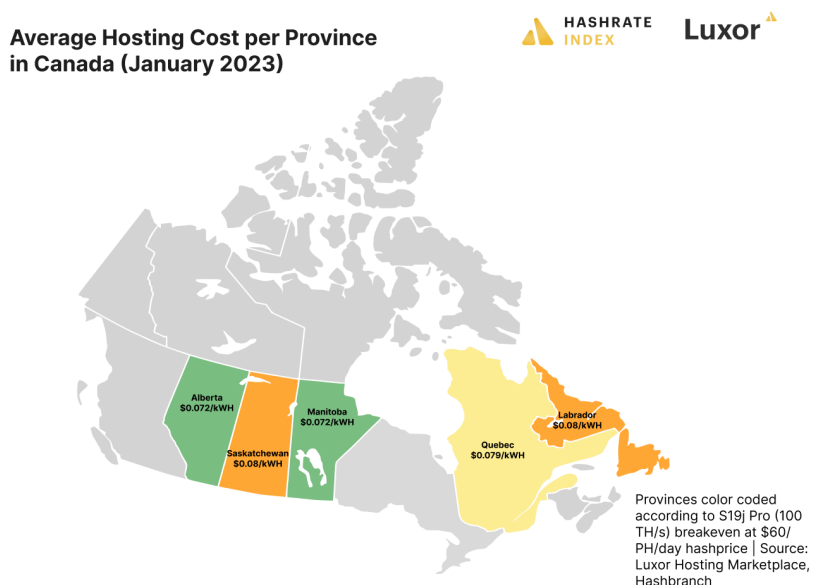
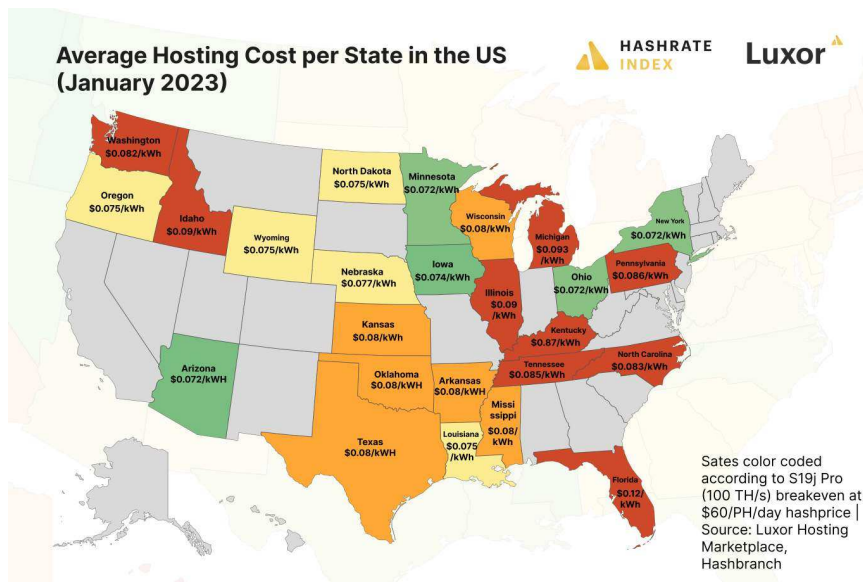
3.5 Hosting rates rise in 2022

With energy prices surging in 2022, hosting costs ballooned as well.

Before 2022's energy price inflation, a reasonable hosting contract might offer power prices at \$0.05-\$0.06/kWh. **Now, it's not uncommon to see \$0.08-0.09/kWh, and many hosting contracts are switching from the standard 'all-in' hosting terms to profit/revenue sharing models. Anything below \$0.075/kWh is considered "a steal" given market conditions.**

In 2021, plenty of miners and hosting providers failed to lock in fixed power purchasing agreements, or they didn't fully understand the variable rates in their contracts. These oversights spelled disaster for certain firms, like Compute North, which filed for bankruptcy in September after power rate hikes put their hosting revenue in the red. Compute North's hosting contracts disallowed it from passing the raised cost on to its clients. Others did pass the buck on to their clients, like Core Scientific, which raised its hosting rates as high as \$0.10/kWh (this didn't save the company from bankruptcy, but more on that later in chapter 4).

Based on analysis that we conducted of public hosting rates from Luxor's ASIC Trading Desk and Hashbranch, the rates for the majority of hosting providers we sampled put miners at breakeven thresholds or underwater for even new-gen machines like the S19j Pro (100 TH/s). Admittedly, this dataset is not comprehensive and the rates are more geared toward small-to-mid-sized operations, but the prices are in line with private rates that Luxor's business team has observed. Below this map, you can see that hosting rates in Canada don't fare much better.



Hosting as a service expanded substantially in North America in 2021 and 2022. Despite the adverse market conditions, we expect hosting services to expand further in 2023 as self-mining companies who lack the capital to fill a facility with their own rigs turn to hosting services to fill up the space. We also expect an increase in available rack space as existing hosts roll out additional capacity.

Some good news for miners in the face of 2022's rising hosting costs: we anticipate that these costs will fall in 2023 as a result of the expansion in capacity discussed above.

Finally, in 2022, we also witnessed more facility operators deploying immersion cooling systems and offering immersion as a hosting option. Immersion cooling allows miners to overclock their rigs to produce higher levels of hashrate. Typically, the hosts will take a small slice of the machine's excess production in addition to the \$/kWh hosting fee. Depending on the percentage the host takes from the rig's overproduction, these deals may work against the miner, since the immersed and overclocked machine consumes more power and the miner is already paying for this excess energy.

4

ASICs are like really expensive paperweights

2022 prices new-gen | mid-gen | old-gen:

Low:

\$14.88/TH | \$9.92/TH | \$4.72/TH
(Dec 26)

Average:

\$55.30/TH | \$35.45/TH | \$15/TH

High:

\$101.04/TH | \$76.10/TH | \$26.53/TH
(Jan 1)

2021 prices new-gen | mid-gen | old-gen:

Low:

\$62.10/TH | \$42.30/TH | \$21.42/TH
(July 15)

Average:

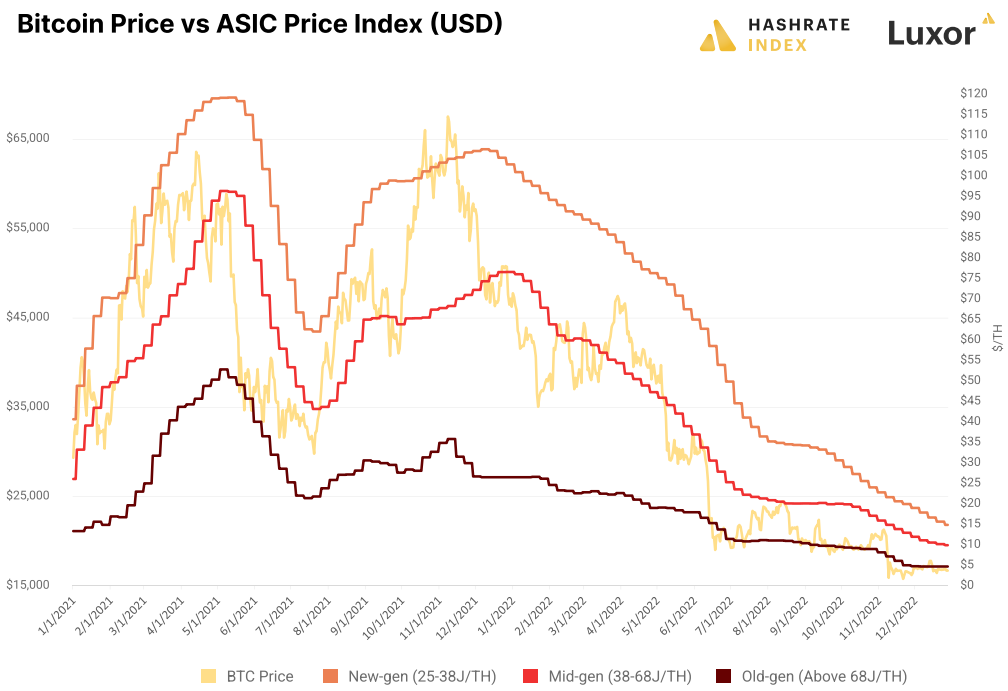
\$92.95/TH | \$64.73/TH | \$30.53/TH

High:

\$119.25/TH | \$96.43/TH | \$52.85/TH
(May 7)

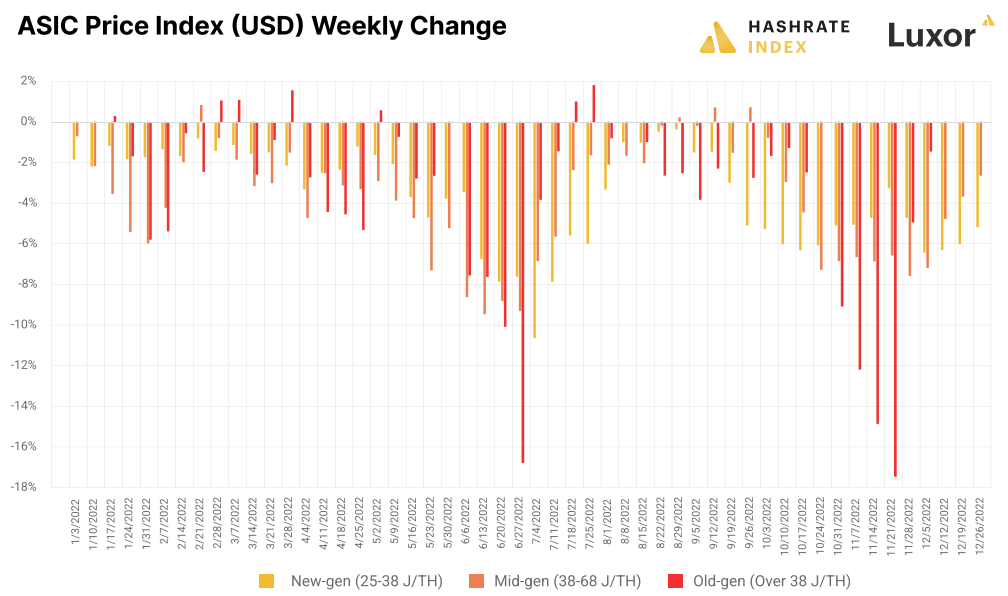
2022 put pressure on every inch of the Bitcoin mining market, and few aspects of the mining market felt this pressure more than the ASIC trade.

In 2021, New-gen (S19, M30 series) and mid-gen rigs (S17, M20 series) hit all-time high values amid the market mania. **In 2022, the bear market drove these rig tiers to all-time lows. New-gen rigs fell 85% from \$101.04/TH to \$14.88/TH, mid-gen rigs fell 87% from \$76.10/TH to \$9.92/TH, and old-gen rigs fell 82% from \$26.53/TH to \$4.72/TH.**



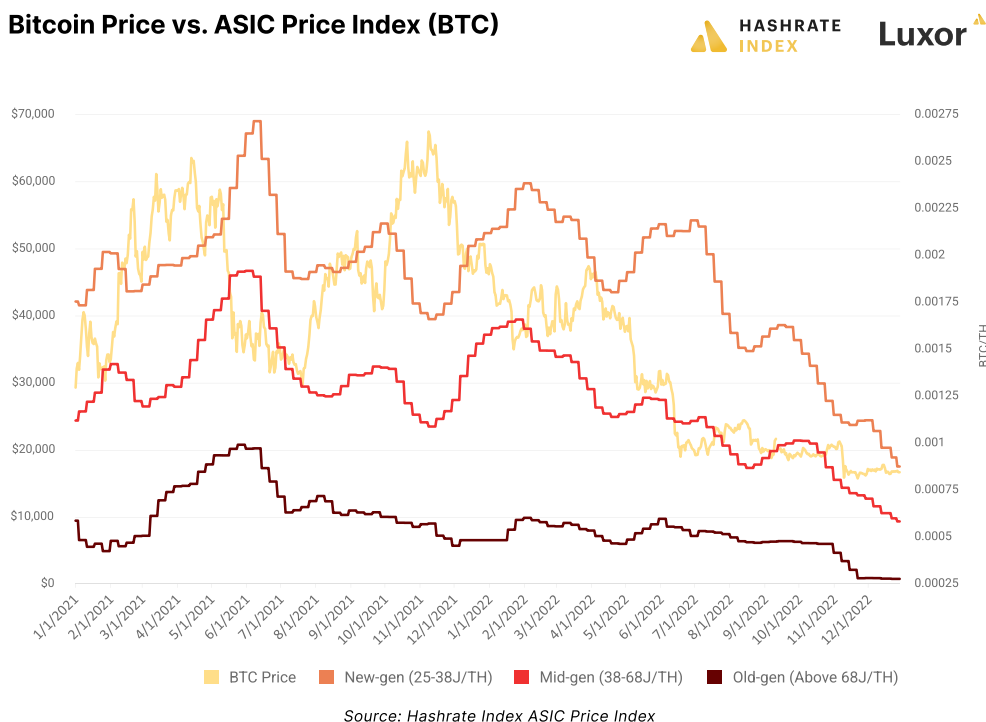
Source: Hashrate Index ASIC Price Index

New-gen rigs did not experience a single week in 2022 where they increased in price. Mid and old-gen rigs had a few weeks of positive price growth, but this is likely in response to weeks where these ASICs were oversold (and it could also be the result of noise in our datasets considering fewer of these older models changed hands in 2022 given the brutal market conditions). For all intents and purposes, the S9, long a darling of miners the world over, is now obsolete except for those miners with dirt-cheap energy.



Source: Hashrate Index ASIC Price Index

Unlike 2021, rig prices in BTC were lower at the end of the year than they were at the beginning – much lower. **New-gen rigs, for example, fell 59% from 0.00214 BTC/TH to 0.00088 BTC/TH.** Rig prices were overheated for most of 2021 and the first half of 2022. The substantial decline in BTC value for these machines perhaps illustrates best that rig prices are cooling down to a reasonable price level relative to current mining economics.



In our analysis, we also found that rigs sold in North America carried a premium to those sold in Asia, in large part due to Trump-era tariffs that increase importation costs from China by 25-30% (Chinese sellers will discount their rigs accordingly to make up for the cost of the tariff). Given that nearly 50% of the industry is concentrated in North America, the premium also makes sense when we consider that North American operators are willing to pay extra for rigs that are already on the continent (and so they have faster shipping times and do not need to go through customs).

Using data from our ASIC Price Index, the average premium (or discount) by quarter for S19j Pros sold in North America vs. Asia are shown below. Q3 was the only period where S19j Pros carried a discount in North American markets. Notably, with the exception of Q3, the premium increased throughout the year.

- Q1: 2.26%
- Q2: 4.12%
- Q3: -0.88%
- Q4: 5.66%

4.1 The 1,000 Day Wait: ASIC ROI Analysis

Rigs have gotten a lot cheaper over 2022, but have prices dropped to a reasonable enough level? Let's see.

One of the most – if not the most – important variables in a miner’s capital expenditure is the timing of their hardware purchases. This timing can make the difference between a machine that pays itself off within the purchase year or one that pays off multiple years later. To illustrate this, we conducted a return on investment (ROI) analysis for an S19j Pro (100 TH/s) for each month in 2021 and 2022, as well as an S19 XP for the last five months of 2022.

In our model, hardware was purchased on the first day of each month based on prices drawn from our ASIC Price Index. Our model deploys this hardware a month after purchase (e.g., a rig purchased on January 1, 2021 was deployed on February 1, 2021), has a power cost of \$0.06/kWh, and assumes 100% up-time. Instead of relying on a static hashprice for 2023 based on December 31, 2022’s hashprice, we project hashprice up until February 1, 2024 using our Hashprice Resistance Model. “Days to ROI” shows the actual ROI time based on historical hashprice data and/or the projected payback period according to our Hashprice Resistance Model. “Expected ROI” shows the expected payback period based on the spot hashprice at the time of deployment.

According to the analysis, the best time to purchase rigs in 2021 was in the first three months of the year OR in July and August, when ASIC prices were still depressed from China’s mining ban. September and Q4 of 2021 was the worst time to purchase rigs, as these timeframes did not ROI before February 1, 2024 (and no rig in these timeframes paid off more than 65% of invested dollars).

In 2022, ROI timeframes are bleaker still. No rig purchased in 2022 ROied by the February 1, 2024 cut off. Rigs purchased between April and July are in particularly bad shape, as rig values in these time frames had not fallen enough to match the realities of the bear market. Toward the end of the year, ROI time frames improved, but they are still substantial given the current market environment. **Looking at this model for December 2022, in order for an S19j Pro to see the same ROI as Q1 of 2021, the price per terahash would need to be in the ballpark of \$5/TH.**

S19j Pro purchase date	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
Days to ROI	184	249	373	1006+	975	945	571	629	853+	822+	792+	762+
% ROI	100%	100%	100%	91%	79%	81%	100%	100%	65%	51%	40%	33%
Expected days ROI	262.0517	266.2593	276.2527	345.42908	640.436	562.9722	233.681	217.5607	354.0812	312.7521	362.2829	523.2602
S19j Pro purchase date	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Days to ROI	730+	701+	671+	641+	610+	580+	549+	518+	488+	457+	427+	396+
% ROI	29%	27%	23%	20%	18%	19%	21%	25%	22%	22%	27%	30%
Expected days ROI	731.736	609.6356	557.7129	710.06952	858.1695	1598.942	793.7826	918.7553	993.6428	1133.788	845.9154	1220.154
S19j Pro purchase date								Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Days to ROI								518+	489+	457+	427+	396+
% ROI								33%	18%	19%	21%	21%
Expected days ROI								1210.934	1116.739	1139.992	927.1226	1279.076

Source: Hashrate Index

It's worth noting that expected ROI goes both ways. In January and February 2021, for example, the expected ROI was longer than actual ROI because Bitcoin's bull market drove hashprice to yearly highs in the first half of 2021; conversely, the expected ROI for rigs when hashprice was skyhigh in 2021 (April, August, October, and November, for example) vastly underestimated payback period for machines purchased these months, as hashprice receded from these highs.

As this analysis suggests, miners should always prepare for the worst when modeling their rig ROIs, and they should *never* project ROI based on spot hashprice at the time of deployment.

4.2 New rigs accelerate the hashrate arms race

Bitmain and MicroBT rolled out next generation hardware in 2022, and not a moment too soon – these new machines will be key for certain miners to survive the bear market.

The much anticipated S19 XP, Bitmain's newest workhorse, first hit racks in July. MicroBT announced the M50 and M50S, the flagships of its forthcoming M50 series, in April. In November, MicroBT also announced the M50S+, a machine powerful and efficient enough to compete with the S19 XP.

These next-gen rigs were at first only available to miners dealing in size enough to order bulk quantities for future delivery. Now, they are trading spot on the secondary market and have become increasingly available to small, mid, and large scale miners alike (the one exception is the M50S+, which was released in November and has not been shipped en masse yet).

New Gen Rigs	Hashrate	Efficiency	Wattage
S19 XP	140 TH/s	21.5 J/TH	3010 W
M50S+	136 TH/s	24.0 J/TH	3264 W
M50S	126 TH/s	26.0 J/TH	3276 W
M50	118 TH/s	29.0 J/TH	3422 W
M30S++	112 TH/s	31.0 J/TH	3472 W
S19 Pro	110 TH/s	29.5 J/TH	3250 W
S19j Pro	104 TH/s	29.0 J/TH	3068 W

Source: Hashrate Index

2022 was also the year that semiconductor stalwart Intel entered the Bitcoin mining ASIC manufacturing game. ePIC Blockchain, Block, Argo, Hive, and Grid were the first to purchase shipments of these chips. Unlike Bitmain and MicroBT, Intel is only manufacturing the chips themselves, not the entire, plug-and-hash rig.

As such, the companies ordering these chips will be tasked with building the rigs themselves. Hive, for instance, deployed 1,423 so-called “HIVE BuzzMiners” that make use of the chips in December 2022 (regrettably, they did not publish efficiency and performance stats for the miners, so they likely do not outcompete hardware from Bitmain and MicroBT). Hive’s BuzzMiners appear to be air-cooled, but other miners will use Intel’s ASICs for immersion setups as well.

4.3 S19 XP commands a sizable premium to other hardware

Hashprice is in the shitter and energy/hosting prices are elevated. Miners are looking for an edge, and new machines are one of the easiest places to find it.

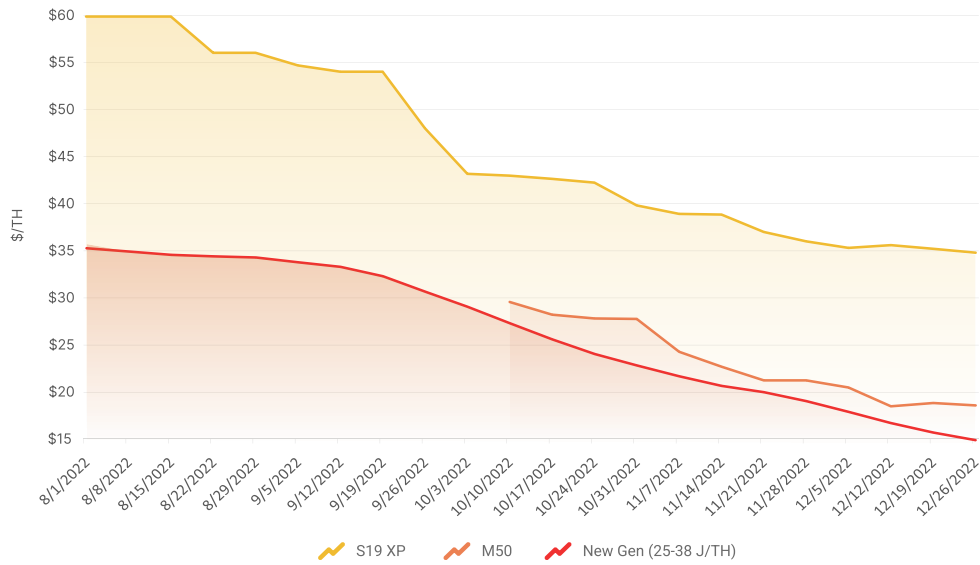
For this reason, the S19 XP has been favored by miners for the edge it gives them in efficiency and power.

When futures orders first cropped up for the S19 XP in November and December of last year, Bitmain discounted the machine compared to spot and even other new-gen futures orders because the first shipments didn’t hit until July/August of 2022. As we discussed in our Q3 report, this discount flipped into a premium at the beginning of the year.

As the year progressed and mining margins continued to dwindle, the S19 XP premium grew progressively larger throughout the year. Pure-play Bitcoin mining companies are pressured to buy XPs if they have higher operating costs, despite their lower expected investment return. This phenomenon has led to a significant divergence in projected investment return for new generation machines and highlights the advantage of lower-cost miners.

Curiously, the premium for MicroBT’s M50 was much less pronounced, most likely because the model’s hashrate, which ranges from 114-120 TH/s, and its efficiency (29 J/TH) is not substantial enough to merit the hefty premium the S19 XP commanded. We do not have any comprehensive data on the M50S because there aren’t enough of these models circulating in the secondary market, and the M50S+ hasn’t shipped yet.

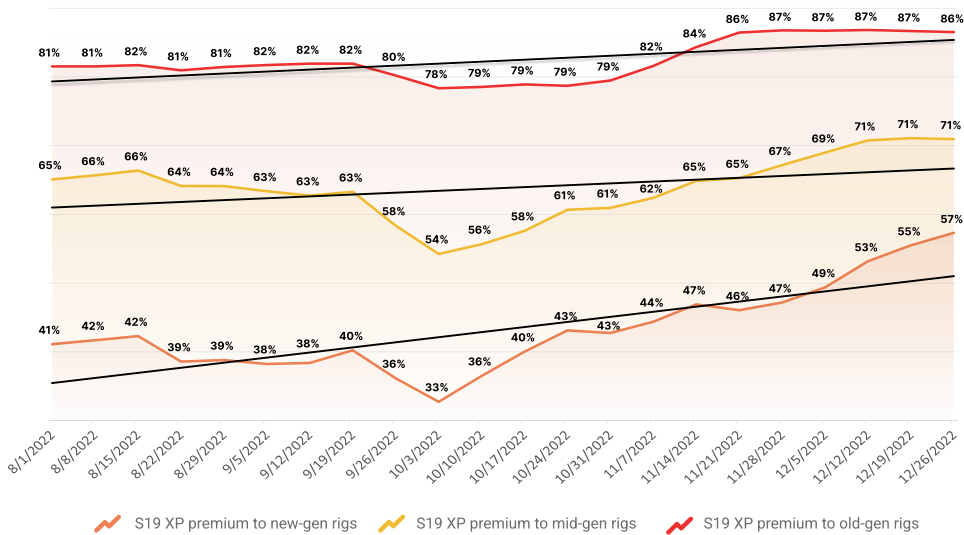
S19 XP, M50, and New-Gen Rig Prices (\$/TH)



Source: Hashrate Index ASIC Price Index

The S19 XP's premium to other rigs only increased as the year went on. Notably, the degree of this premium to new-gen (25-38 J/TH) rigs increased significantly in November after hashprice hit its all-time low, indicating that miners are increasingly eager to purchase the S19 XP over new-gen rigs. This is not a surprise: just as prices for the S19j Pro and other new-gen hardware quickly grew into a premium to the S17 / mid-gen rigs and the S9 / old-gen rigs, so too is the S19 XP enjoying a premium

S19 XP Premium to new (25-38 J/TH), mid (38-68 J/TH), and old-gen (68+ J/TH) rigs



Source: Hashrate Index ASIC Price Index

This premium also means that in the case of a strong uptick in mining economics, the XPs will have a smaller beta (correlation) to hashprice than mid-gen and old-gen machines. This is in line with historical trends where demand for new generation machines suppresses price volatility.

4.4 Bitmain, MicroBT will cut supply in 2023

In the lingering fog of COVID-related supply chain issues, ASIC chip shortages have hung on the necks of every major industry like a ghostly albatross.

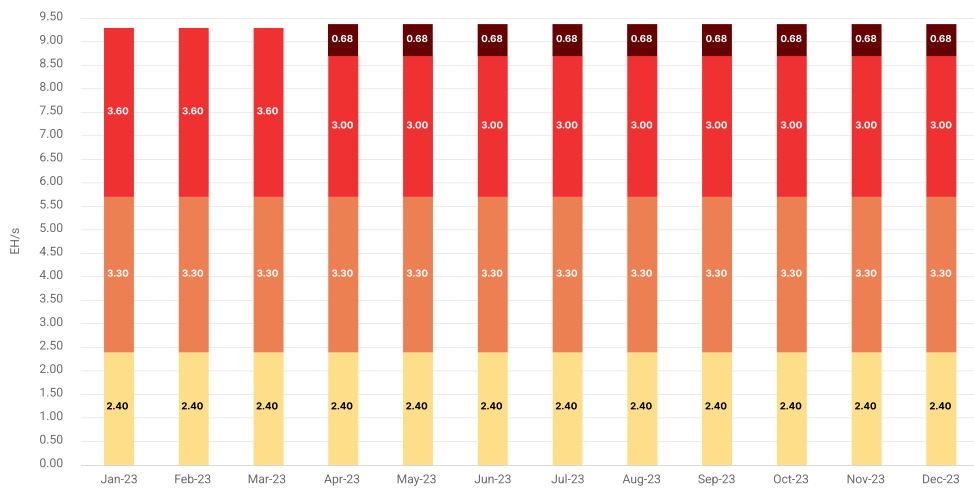
The shortage could become a surplus in 2023 and 2024 – or at the very least, supply and demand may reach an equilibrium. One survey found that 65% of semiconductor executives believe that the shortage will cease in 2023, and a forecast from Gartner predicts a 3.6% contraction in industry revenue in 2023.

TSMC, SMIC, Samsung, and Intel have been ramping up supply as they shrug off COVID restrictions and raw material shortages. At the same time, economic activity is slowing as consumers and businesses brace for a global recession, so demand is ramping down as supply is ramping up.

This means that mining rig manufacturers like Bitmain and MicroBT (who are last in line for chips like these anyway) will have more access to chips next year, but this is coming at a time when demand for Bitcoin mining rigs is depressed, as well.

Both manufacturers will be cutting supply in 2023 accordingly, and we estimate that Bitmain could be reducing its output by as much as 40% (estimates based on business intel from Luxor’s ASIC Trading Desk). Per these estimates, Bitmain could produce as much as 48,000 machines per month, and MicroBT could produce as much as 30,000 per month.

Bitmain, MicroBT estimated monthly production (in EH/s)



Source: Luxor ASIC Trading Desk

■ S19 ■ S19 XP ■ M50 ■ M50S+



5

Public miners face their toughest year yet

In 2022, more bitcoin mining stocks traded on public markets than ever before since public mining companies began cropping up in 2017. For some, it was their first full trading year - and it could also be their last.

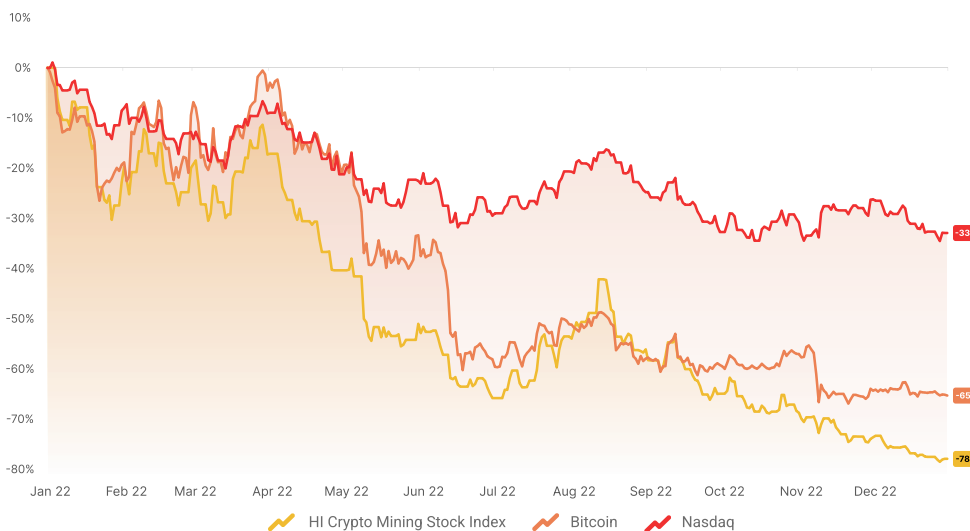
This chapter analyzes performances, news and trends regarding public miners in 2022.

5.1 Mining stocks had a horrible year

It's hard to imagine how 2022 could have been any worse for bitcoin mining stocks. It was a year of severe margin compression for mining companies due to a lethal combination of bitcoin's falling price, growing hashrate, rising energy costs, and deteriorating access to capital. It ultimately resulted in several public miners *almost* going belly up, and the biggest of them going bankrupt.

Hashrate Index's Crypto Mining Stock Index fell by a staggering 78% in 2022, compared to a 65% drop in the bitcoin price and a 33% decline of the Nasdaq. It's well known that mining stocks can give investors high beta exposure to bitcoin. Unfortunately, this high beta property also holds true during the worst of bitcoin bear markets, meaning that the severe underperformance of mining stocks relative to bitcoin in 2022 was not unexpected. **In 2022, the daily correlation between the Hashrate Index Crypto Mining Stock Index and bitcoin was 0.96.**

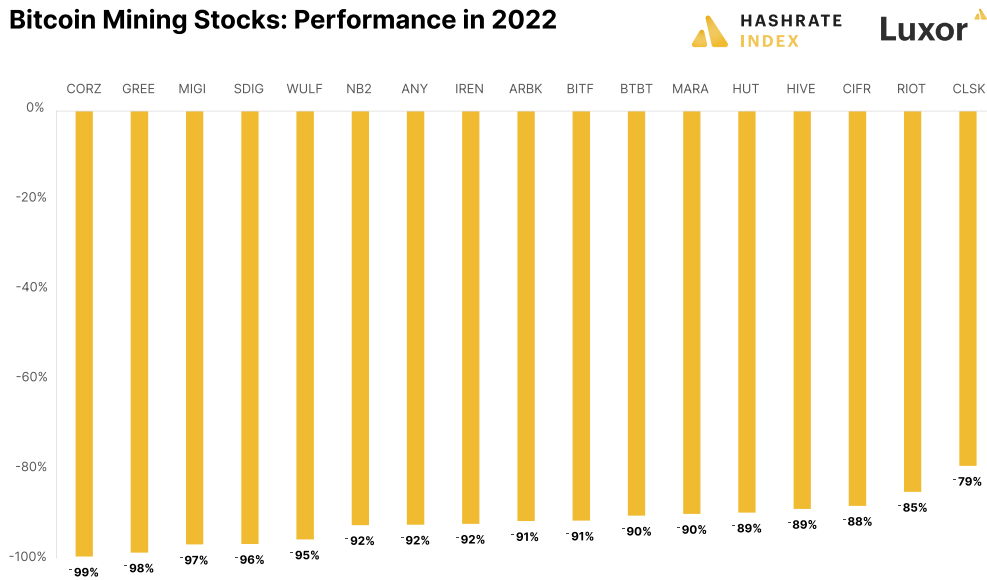
2022 Performance: HI Crypto Mining Stock Index vs Bitcoin vs Nasdaq



Source: Tradingview, Hashrate Index Crypto Mining Stock Index

Let's look at the individual performances of bitcoin mining stocks. While our Crypto Mining Stock Index fell by 78% in 2022, the harsh reality is that most bitcoin mining stocks declined by more than that. The Crypto Mining Stock Index has significant holdings of chip manufacturers which have performed considerably better than the companies whose business models are solely focused on bitcoin mining.

As shown in the chart below, most pure-play bitcoin mining stocks fell by 90% or more in 2022. Core Scientific (CORZ) performed the worst, with its stock plummeting by 99%. The company is currently going through a Chapter 11 bankruptcy, which we explain more closely in chapter 6 section 3. The second-worst performer was Greenidge Generation (GREE), a natural-gas power plant operator turned bitcoin miner. Its stock plunged by 98%, as the company struggled under a mountain of high-interest rate machine-collateralized debt, which you can read more about in chapter 6.1



Source: Tradingview

All bitcoin mining stocks performed horribly in 2022. The “best” performer was CleanSpark (CLSK), whose stock fell by 79%. During this bear market, CleanSpark has expanded heavily by buying ASICs and facilities from distressed companies at bear market valuations. Even though the company has been one of the biggest diluters in 2022, its stock has performed the best, signaling that shareholders believe in the company’s bear market growth strategy.



Source: Tradingview

The once mighty valuations of bitcoin mining companies evaporated as stock prices plummeted. **At the peak of the bull market in November 2021, the total market cap of bitcoin mining stocks stood at more than \$30 billion. Currently, this number sits below \$3 billion, revealing the massive capital destruction that took place in the bitcoin mining industry in 2022.**

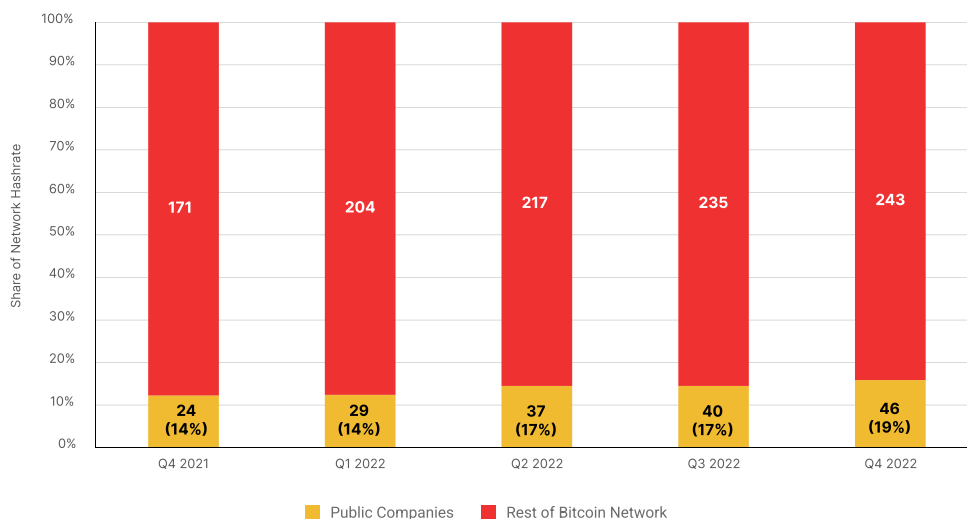
As 2022 kicked off, some public miners were in the process of making a name for themselves. Marathon had a market cap of \$3.4 billion, which is higher than the current total market cap of all bitcoin mining stocks. Back then, now-bankrupt Core Scientific had a market cap of \$2.8 billion, while Riot’s market cap was \$2.7 billion.

After a year of enormous capital destruction for the public miners, Riot and Marathon are now the only mining stocks with relatively significant market caps. All other mining stocks have been reduced to micro caps (below \$300 million market cap). **Many of these stocks exited 2022 below Nasdaq’s listing requirement of \$1 per share, including Core Scientific, Bitfarms, Stronghold, Cipher, Greenidge, Sphere 3D, Terawulf, Bit Digital, Hut 8, and Mawson.** Unless mining conditions significantly improve in the near future, we expect Nasdaq to delist some of these miners. Certain public miners might also voluntarily go private to lower administrative costs and ease their burden of having to satisfy a larger, public investor base. (We unpack this prediction in the chapter 9).

5.2 Public miners expanded as quickly as possible

Driven by market incentives, public miners expanded as quickly as possible in 2022, mostly with hardware that was pre-ordered in 2021. As you can see on the chart below, public miners started the year producing 14% of Bitcoin’s hashrate, and ended the year at 19%. This increase in their share of global hashrate means that they expanded capacity much faster than the private miners in 2022. The public miners increased their cumulative hashrate by 59% in 2022, compared to private miners’ 19% hashrate growth.

Public Miner Hashrate vs. Bitcoin Network Hashrate (EH/s)

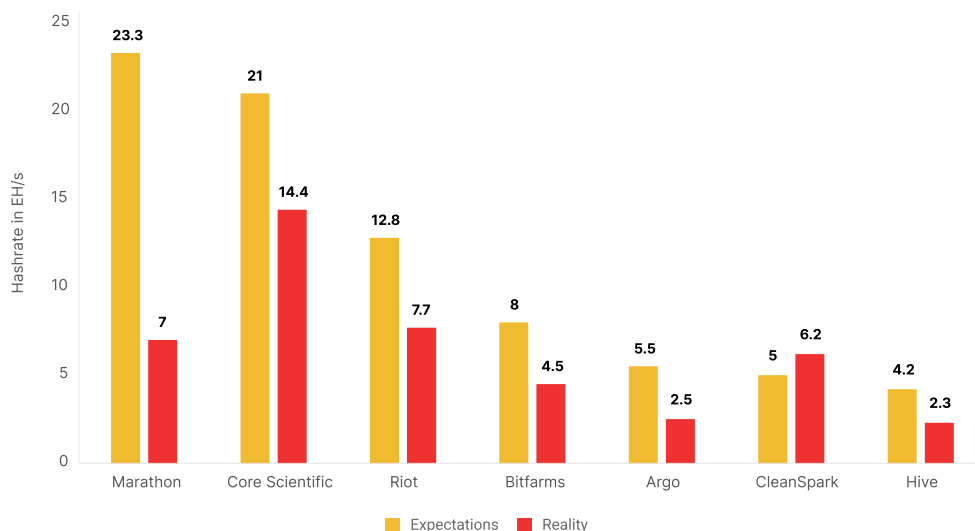


Source: Public miner disclosures, Hashrate Index

Why did public miners expand so much faster than private miners in 2022? It all comes down to cost of capital. Elevated mining margins in 2021 combined with a general stock market boom gave public miners the opportunity to raise huge amounts of capital in 2021 from mining stock investors that demanded growth. The public miners did as the market demanded, and spent the raised capital on enormous future machine orders that were delivered in 2022. Since the private miners were not able to tap into the historically hot equity markets in 2021, they were spared from making the same enormous machine orders as the public miners.

In 2023, we expect the public miners' share of the Bitcoin hashrate to keep increasing. Most of these miners came nowhere close to reaching their capacity expansion plans for 2022, leading them to push these plans to mid-2023. Rising energy costs, build-out delays, and other disruptions hampered hashrate growth for certain public miners in 2022.

Year-End 2022 Hashrate: Expectations vs Reality



Source: Public miner disclosures

The chart above compares the public miners' stated hashrate goals for year-end 2022 with their actual hashrate at this time. All the miners in the chart, except for CleanSpark, were far from reaching their 2022 hashrate goals. Marathon was the furthest away from reaching its goal, as it aimed to have 23.3 EH/s plugged in by year-end 2022 but only achieved 7 EH/s.

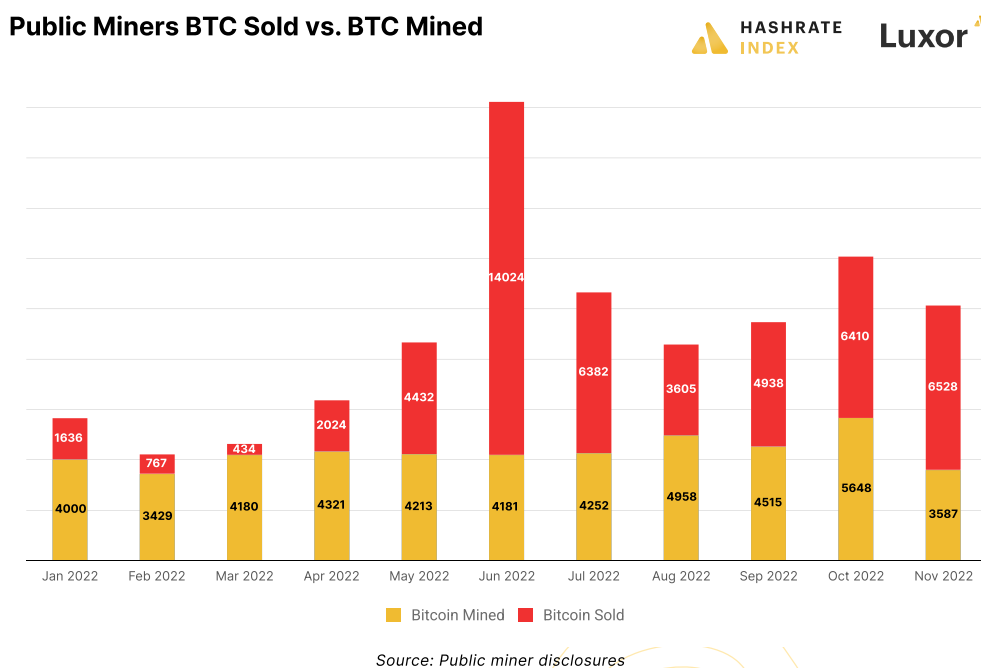
These massive divergences between hashrate expansion plans and actual results should teach investors how challenging it is to grow a mining operation. Many things can go wrong when developing and operating the physical infrastructure necessary to support a mining operation, particularly for miners of this scale – particularly when relying on many third-parties. Marathon's self-proclaimed asset-light strategy, which relies on hosting companies, has shown its weaknesses as the company has struggled getting their ASICs up and running due to problems with hosting partners (principally, the bankruptcy of Compute North).

5.3 Public miners held the top in 2021, and (basically) sold the bottom in 2022

The hodl strategy is a mining treasury strategy centered around holding as much mined bitcoin as possible. This strategy became popular for public miners during the bull market of 2021, as there was strong market demand for publicly listed bitcoin investment vehicles. Many investors invested in public miners as a way to get bitcoin exposure.

The hodl strategy worked well in 2021 when the bitcoin price increased and miners could tap into historically strong equity and debt markets to pay for investments and operating expenses without selling bitcoin. Most public miners followed this strategy and built up enormous bitcoin treasuries consisting of thousands of bitcoin. Bitfarms even went as far as buying 1,000 bitcoin in early 2022.

As the bitcoin price fell in 2022, the hodl strategy started showing its downsides. Miners didn't have access to the same equity and debt financing as in 2021, and suddenly we saw several of the seemingly strongest hodlers offload their bitcoin holdings. Companies like Core Scientific and Bitfarms dumped thousands of bitcoin from May onwards.



As shown on the chart above, public miners started dumping their holdings in May, the first month they sold more bitcoin than they produced. In June, a time when Bitcoin broke through \$30,000 and down to \$20,000, the selling took off: public miners dumped 14,024 bitcoin, well over 3 times their monthly production of 4,181 bitcoin. This was forced selling to pay down equipment loans, other debt burdens, and operational costs.

As the year went on, public miners kept draining their holdings, selling more bitcoin than they generated. **Between January and November, public miners offloaded 51,180 bitcoin, while producing 47,284 bitcoin.**

Only a small group of miners were able to keep their stacks in place. Hut 8, Riot, Hive, DMG, and Marathon were the core group of miners that kept their bitcoin treasuries mostly in-tact (Hut 8 was the only miner that didn't sell any BTC last year).

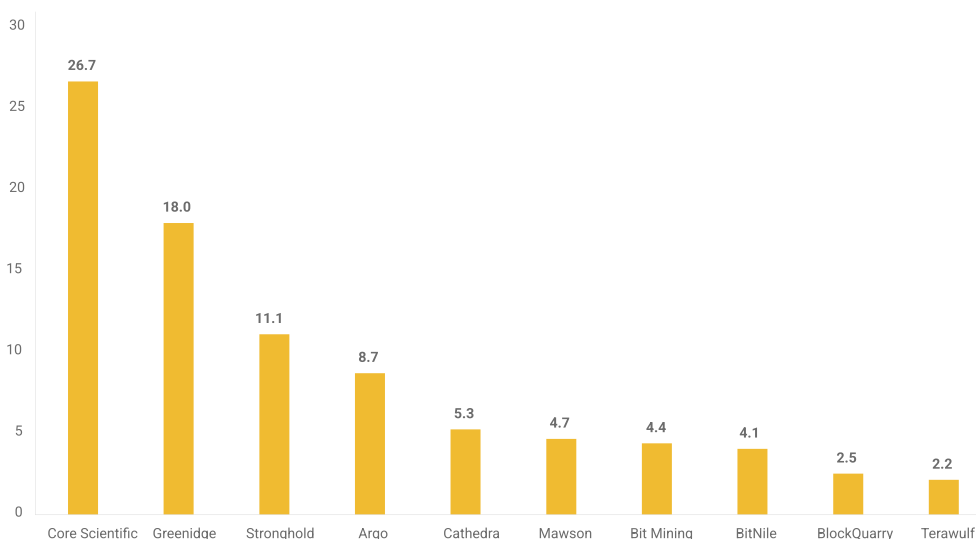
As we explain in chapter 9, 2022 should serve as a painful case study for miners on how to not manage a bitcoin treasury. We expect treasury management to be a key focus for public and private miners in 2023 and beyond. As part of a holistic risk management strategy, which is common in more mature commodity producing industries, many miners will consider hedging hashprice, as the necessary derivatives solutions are now available.

5.4 Many public miners are struggling with weak balance sheets

The biggest challenge for most public miners in 2022 was their massive debt levels relative to equity. These companies seemed to have their debt burdens under control at the start of the year, as their equity valuations were high and they generated solid cash flows from operations. As the year went on with deteriorating market conditions and plummeting equity valuations, the seemingly low debt levels of these companies suddenly became elevated relative to their equity.

The chart below shows the top 10 public miners by debt-to-equity ratio. As you can see, a handful of miners have debt-to-equity ratios above 5. In most industries, 2 is considered a high debt-to-equity ratio. Core Scientific and Greenidge have the highest debt-to-equity ratios of 26.7 and 18. Consequently, Core Scientific is now bankrupt and Greenidge has undergone debt restructuring.

Public Miners: Top 10 by Debt-to-Equity Ratio

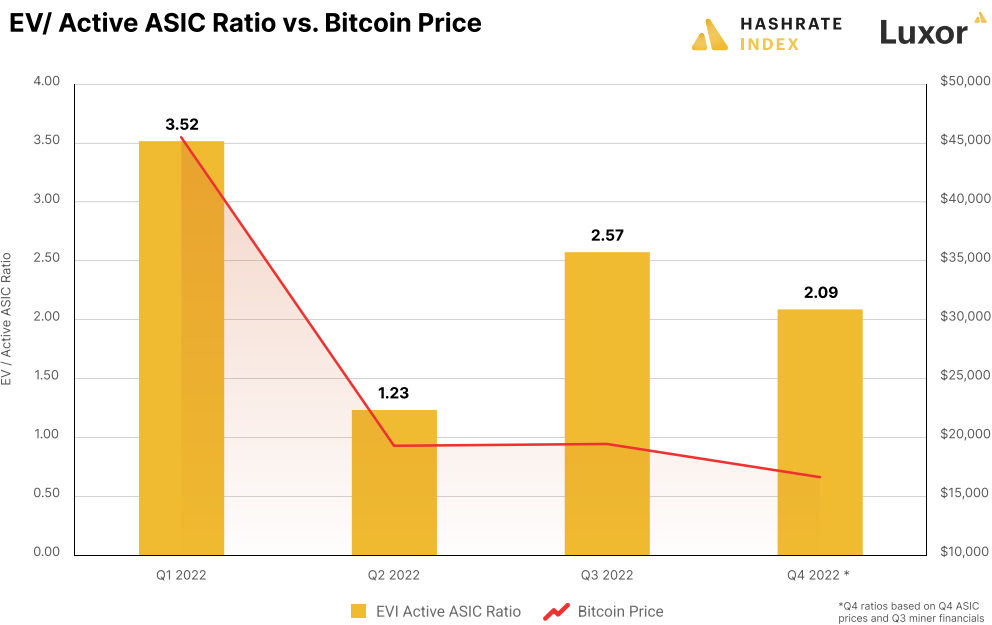


Source: Tradingview, public miner financial statements

As 2022 came to a close, companies with high debt-to-equity ratios were ravaged by falling hashprice. All but one of the miners listed above had to reorganize their business by the end of the year. The one that didn't, Core Scientific, became insolvent by December and filed for Chapter 11 shortly thereafter. Stronghold defaulted on their equipment loans. By defaulting on their equipment loan, Stronghold was required to return over 26,000 miners to NYDIG. Argo Blockchain was at risk of filing for Chapter 11, as their free cash flow was not able to cover large equipment loans. Fortunately, Galaxy Digital Mining stepped in, acquiring their Helios facility in Texas. With Argo Blockchain bagging \$65 million in cash and a \$35 million loan in the deal, they averted a likely Chapter 11 reorganization.

Mining stock valuations have plummeted as the bear market has handicapped stock prices. We can use several metrics to track the valuations of bitcoin mining stocks, and one of our favorites is based on the market value of the ASICs these companies hold. At its core, a bitcoin mining company owns ASICs and attempts to operate them as cheaply as possible to generate bitcoin at a profit.

In 2022 we introduced a new metric called the EV/Total ASIC Value ratio. The purpose of this ratio is to provide a clearer operational value relative to the debt and cash on a miner's balance sheet. If the ratio is trending down, it means investors are pricing in lower expected values due to bitcoin price and difficulty changes, and lower values for mining rigs. If the ratio is trending higher, investors are expecting better mining margins and likely higher bitcoin prices.



Source: Public miner disclosures, ASIC Price Index

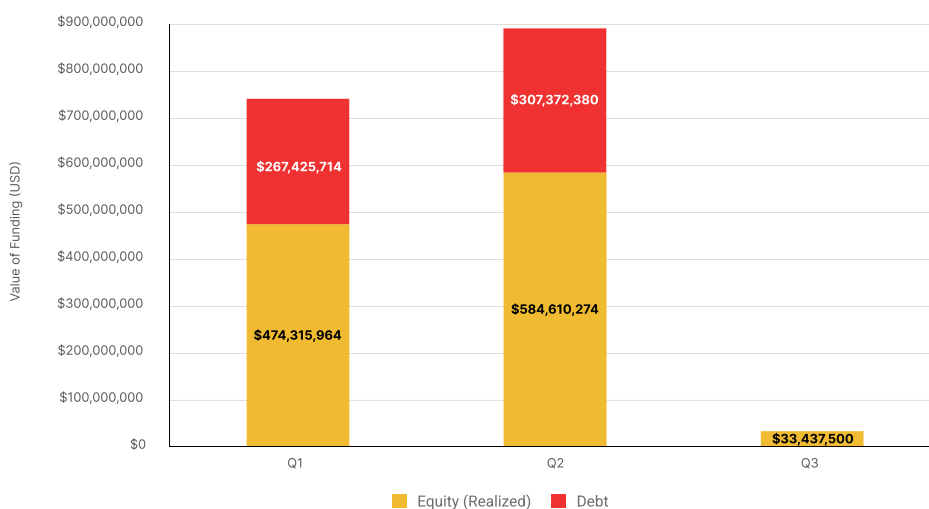
Based on the chart above, investors can see the various upwards and downward adjustments quarter over quarter. During the first half of the year, the bitcoin price was much higher and investors placed higher expected values on mining stocks, with the EV/ Total ASIC Value sitting at 3.52. As the bear market clawed its path in Q2 2022, the EV/ Total ASIC ratio hit 1.23, its lowest level of the year.

As the bear market continued the rest of the year, the ratio adjusted a bit higher reflecting cash on hand being used for fleet growth, while simultaneously mining rig values fall sharply.

5.5 Capital dries up

Part of the reason why public miners started to struggle in 2022 was that their capital tap was shut off. For the past two years, public miners became accustomed to strong equity and debt markets. **As you can see in the chart below, public miners raised \$750 million in Q1 2022 and \$900 million in Q2 2022, mostly consisting of equity. In Q3, they only managed to raise \$33 million.**

Public Miner Debt and Equity Raises by Quarter 2022



Once the bear market came into full effect in June, financing deals immediately dried up. Bitcoin miners were no longer had access to cheap debt as the Federal Reserve started raising rates. As an alternative for the last half of the year, many Bitcoin miners announced at-the-market offerings to shore up their liquidity. These equity offerings are like a revolving line of credit, wherein a company creates an open offer that investors can buy into until the ATM reaches a certain cap or expires. Major public Bitcoin miners secured these types of financing arrangements at the detriment of long-term equity investors who suffered from dilution. As the crypto winter continues into 2023, more unused ATM equity facilities will be used to shore up finances and survive the winter.

Recently, Cleanspark raised more ATM equity funding through an \$500 MM offering from HC Wainwright. **Entering 2023, there is at least \$2 billion in potential equity funding available to the top public Bitcoin miners.** Based on public disclosures, the following table shows the significant amount of funding available through ATM shelf offerings for public Bitcoin miners, as well as an estimate based on filing information for how much ATM funding public miners have tapped.

Company	Q1, Q2-2022 Total At-the-Market Offerings	Used to date (estimated)
Bitfarms	\$500,000,000	\$295,000,000
Hut 8	\$200,000,000	0
Marathon Digital	\$750,000,000	\$161,000,000
Core Scientific	\$100,000,000	0
Riot Blockchain	\$500,000,000	\$272,000,000
Hive Blockchain	\$100,000,000	0
Cleanspark	\$200,000,000	\$92,769,711
Total	\$2,350,000,000	\$820,769,711

Source: Public filings



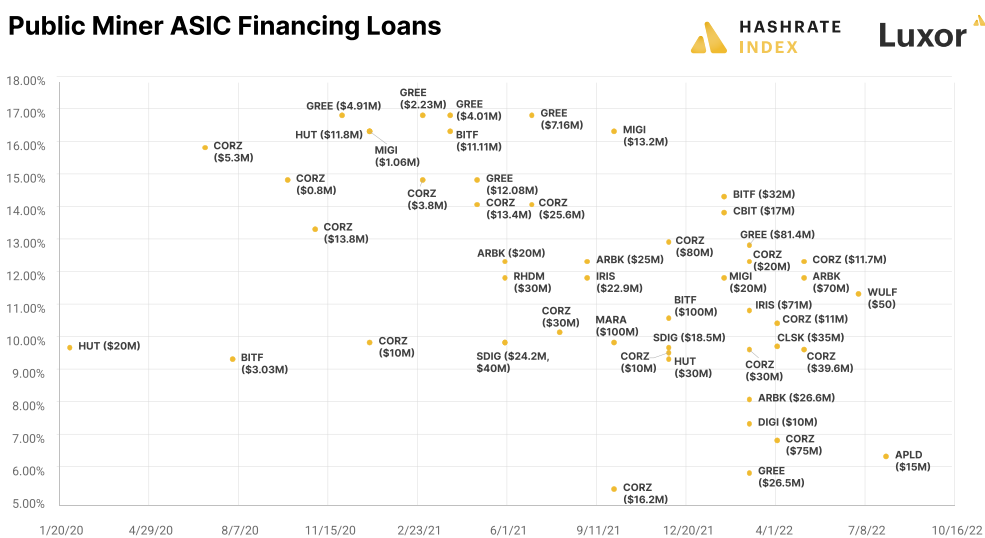
6

Pigs Get Fat, Hogs Get Slaughtered

Driven by public market incentives, many public miners fattened their hashrate with growth-at-all-cost strategies in 2021. They fed operations with a goulash of fundraising that included equity sales, traditional borrowing, and equipment-financing.

Servicing debt became difficult for some of these miners in 2022, particularly those with outsized, high-interest equipment financing loans. We estimate that there is between \$2-4 billion worth of ASIC financing debt on private and public miner balance sheets.

Courtesy of [TheMinerMag](#), the chart below shows ASIC financing deals for public miners from 2020 to present. **Six ASIC financing deals were executed in 2020 worth \$47.84 million, while 2021 saw the lion's share of deals: 26 worth \$662.25 million. There were 18 deals in 2022 worth \$641.80 million, 16 (\$576.80 million) of which were made in the first half of the year, as deal flow dried up in the second half as market conditions went from bad to horrendous.**



Source: TheMinerMag, public filings

More equipment financiers have entered the game since 2020, and this has driven down the average interest rate from 12.77% in 2020 and 12.82% in 2021 to 10.46% in 2022. Even so, 2022's average is still steep for a capital intensive industry with thinning margins.

No doubt, as margins dwindled and payments came due in 2022, a number of miners defaulted on these loans. **Our tally (of known defaults from public miners) puts the total default amount at \$227.4 million on the low end and \$238.4 million on the high end.** In the case of default, the financed ASICs end up in the hands of their financiers, as many of these loans are collateralized with the ASICs themselves.

Miner	Lender	Amount	ASICs in Default
Iris Energy	NYDIG	\$71 million	~20,000
Greenidge	48.11	\$57-68 million	~28,000
Stronghold	3.65	\$67.4 million	26,200
Iris Energy	23.46	\$32 million	~16,000

Source: Public disclosures

Indeed, ASIC financiers themselves clawed back several exahashes worth of equipment in 2022. Rather than let this equipment idle, firms like NYDIG, Galaxy, and Foundry are putting it to use. Foundry, for example, purchased two facilities (and potentially a third) in Compute North’s bankruptcy auction, and Galaxy acquired Argo’s Helios facility as well.

Just as 2022 will likely serve as a case study for how *not* to manage a BTC treasury, it should also cause ASIC financiers to rethink equipment loans. We expect that such loans in the future will favor more liquid and robust collateral than ASICs.

6.1 ASIC loan analysis: borrowers are underwater on payments

To evaluate the health of ASIC-backed loans, Luxor analyzed hypothetical debt service coverage ratios (DSCRs) for loans underwritten since the beginning of 2021. DSCR is a common metric used to assess a borrower’s ability to meet its debt obligations based on their cash flow.

A DSCR above 1.00x indicates that cash flow is sufficient to cover debt costs, while a ratio below 1.00x indicates a borrower needs to use balance sheet funds (or raise additional capital) to pay for debt costs.

Monthly DSCRs were calculated using the below formulas:

$$DSCR = \text{Miner Margin} \div \text{Debt Service}$$

$$\text{Miner Margin} = \$ \text{ Hashprice} \times \text{Machine TH/s} - \text{Machine kW} \times 24 \text{ Hours} \times \text{Electricity Rate} \times 30 \text{ Days}$$

$$\text{Debt Service} = \$ \text{ per TH Machine Price} \times \text{Loan to Value \%} \div \text{Tenor} + \text{Interest Rate} \div 12 \times \text{Loan Balance}$$

For miner margin, we used machine specifications for the S19 Pro (100 TH, 3.25 kW) and an electricity rate of \$0.05 per kWh. Machine pricing from the Hashrate Index ASIC Price Index and a 75% loan-to-value were used to calculate debt amounts. Debt matured over 18-months with equal monthly amortization payments. Finally, interest expense was calculated by applying a 15% interest rate to the average loan balance between the beginning and end of the month. The results using these assumptions are shown in the table below.

(1)	(2)	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	
Jan-21	59	2.07x	2.81x	3.23x	3.38x	2.48x	2.15x	2.99x	3.83x	3.03x	3.76x	3.43x	2.52x	1.91x	1.79x	1.86x	1.73x	1.15x	0.74x							
Feb-21	75		2.18x	2.50x	2.62x	1.92x	1.67x	2.32x	2.82x	2.35x	2.91x	2.66x	1.95x	1.48x	1.39x	1.44x	1.34x	0.89x	0.58x	0.58x						
Mar-21	100			1.86x	1.94x	1.43x	1.24x	1.72x	2.09x	1.74x	2.16x	1.97x	1.45x	1.10x	1.03x	1.07x	0.99x	0.66x	0.43x	0.43x	0.45x					
Apr-21	116				1.66x	1.22x	1.06x	1.47x	1.79x	1.49x	1.85x	1.68x	1.24x	0.94x	0.88x	0.91x	0.85x	0.57x	0.36x	0.37x	0.38x	0.27x				
May-21	118					1.19x	1.03x	1.43x	1.74x	1.45x	1.80x	1.64x	1.20x	0.91x	0.86x	0.89x	0.82x	0.55x	0.35x	0.36x	0.37x	0.26x	0.22x			
Jun-21	94						1.28x	1.77x	2.15x	1.79x	2.22x	2.03x	1.49x	1.13x	1.06x	1.10x	1.02x	0.68x	0.44x	0.44x	0.46x	0.32x	0.27x	0.17x		
Jul-21	66							2.52x	3.05x	2.54x	3.15x	2.87x	2.11x	1.60x	1.50x	1.56x	1.45x	0.96x	0.62x	0.62x	0.65x	0.46x	0.38x	0.25x	0.28x	
Aug-21	80								2.48x	2.06x	2.56x	2.33x	1.72x	1.30x	1.22x	1.26x	1.17x	0.78x	0.50x	0.50x	0.53x	0.37x	0.31x	0.20x	0.23x	
Sep-21	97									1.68x	2.08x	1.90x	1.39x	1.06x	0.99x	1.03x	0.95x	0.63x	0.41x	0.41x	0.43x	0.30x	0.25x	0.16x	0.18x	
Oct-21	100										2.00x	1.82x	1.34x	1.02x	0.95x	0.98x	0.91x	0.61x	0.39x	0.39x	0.41x	0.29x	0.24x	0.15x	0.18x	
Nov-21	105											1.73x	1.27x	0.96x	0.90x	0.93x	0.87x	0.58x	0.37x	0.37x	0.39x	0.27x	0.23x	0.15x	0.17x	
Dec-21	105												1.25x	0.95x	0.89x	0.92x	0.85x	0.57x	0.37x	0.37x	0.38x	0.27x	0.22x	0.14x	0.16x	
Jan-22	99													1.00x	0.94x	0.97x	0.90x	0.60x	0.39x	0.39x	0.40x	0.28x	0.23x	0.15x	0.17x	
Feb-22	92														0.99x	1.03x	0.95x	0.63x	0.41x	0.41x	0.43x	0.30x	0.25x	0.16x	0.18x	
Mar-22	87															1.08x	1.00x	0.66x	0.43x	0.43x	0.45x	0.31x	0.26x	0.17x	0.19x	
Apr-22	79																1.09x	0.72x	0.47x	0.47x	0.49x	0.34x	0.28x	0.18x	0.21x	
May-22	72																	0.79x	0.51x	0.51x	0.53x	0.37x	0.31x	0.20x	0.23x	
Jun-22	58																		0.62x	0.62x	0.65x	0.45x	0.37x	0.24x	0.28x	
Jul-22	41																			0.87x	0.91x	0.64x	0.53x	0.34x	0.39x	
Aug-22	35																				1.07x	0.75x	0.62x	0.40x	0.45x	
Sep-22	33																					0.78x	0.64x	0.42x	0.47x	
Oct-22	27																						0.79x	0.51x	0.58x	
Nov-22	21																							0.64x	0.73x	
Dec-22	17																								0.91x	

(1) Date refers to the month in which the loan was issued; (2) Indicates the average \$/TH price for machines during the month of loan issuance

DSCRs remained healthy across all months in 2021. In early 2022, DSCRs for loans issued in months where machine prices were above 100 \$/TH began to dip below 1.00x, indicating miners were unable to service the larger loans they received to buy machines during peak pricing periods. **After hashprice nosedived in June 2022, all loans fell below the 1.00x DSCR mark (with the exception of a single datapoint in August).**

In essence, this means that any miners with a similar loan profile as the one in our model (75% LTV, 15% interest rate, 18 month tenor) are unable to service the loan's debt using mining revenue. They would need to come up with the cash elsewhere, or default on the loan to wipe away the debt.

As defaults occur, operators on more sound financial footing will be well-positioned to scoop up machines at bargain prices as lenders liquidate collateral to recover what funds they can. With this in mind, it's reasonable to expect more distressed asset sales in 2023. Based on our ASIC Trading desk data, distressed assets usually sell for 10-25% less than fair-market-value if the seller needs to liquidate a large volume into the market with an immediate sale.

6.2 Acquisitions and distressed asset sales

Miners came under significant financial stress in 2022, and for some, this ended in distressed asset sales. The most consequential of these asset sales include Compute North's 363 asset sale, which saw Compute North's datacenters divvied up between its creditors; Galaxy's \$65 million purchase of Argo's immersion-outfitted Helios facility in Texas; and Cleanspark's acquisition of a Mawson facility in Sandersville, GA and Waha Technology's Washington, GA facility.

Buyer	Seller	Asset	Amount	Additional Info
Galaxy	Argo	Helios mining facility (180MW running, up to 800 MW)	\$65M	
Cleanspark	Mawson	Sandersville, GA facility (80 MW running, up to 230 MW)	\$42.5M	
Cleanspark	Waha Technologies	Washington, GA facility (36 MW running, up to 86 MW)	\$25.1M	
Hut8	TeraGo	5 datacenters	\$24M	
Generate Capital	Compute North	Kearny, NB facility (100 MW) + Granbury, TX facility (up to 300 MW)	\$101M (value of loan)	Facilities were collateral for GC's \$101M loan to CN
US Data Group	Compute North	McCamey, TX Facility (up to 280 MW)	\$10M + assumed \$99M loan	USDG assumed NextEra's \$99M loan to CN
Foundry	Compute North	3 mining facilities (up to 52 MW)	\$5.17M	Foundry may only purchase 2 of 3 facilities
Crusoe	Compute North	11 Bitcoin mining containers	\$1.55M	
Crusoe	GAM	GAM	undisclosed	
BIT Mining	Bee Computing	Bee Computing	Up to 22.9M shares	BIT Mining shares issued to Bee Computing
Akron Energy	Hydrokraft AS	Hydrokraft AS data center (30 MW running, up to 80 MW)	undisclosed	

Source: Press releases, public disclosures

The above table is not exhaustive, as there were no doubt more acquisitions between private miners that went unannounced, not to mention smaller deals that didn't merit publicity.

Additionally, a handful of investment funds surfaced in 2022 to invest in distressed mining assets, including one from [DCG](#) and another from [Jihan Wu](#). We expect that acquisitions, distressed asset sales, and mergers will be a notable trend in 2023 as market conditions flush-out inefficient operators. These sales could help set a price floor for mining rigs sold in the secondary market. As with 2022, the most coveted assets will be turn-key Bitcoin mining facilities.

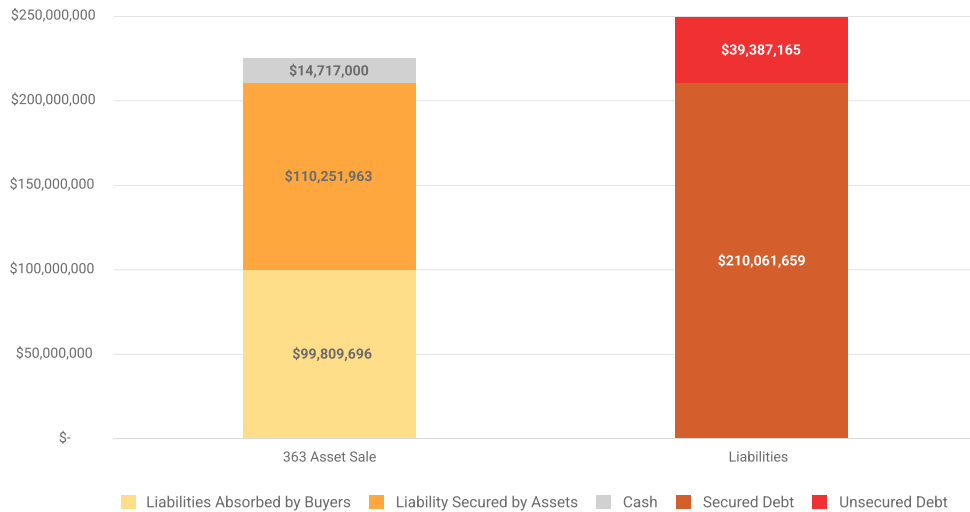
6.3 North America's largest hosting providers go bankrupt

Two major mining bankruptcies erupted in 2022.

The first came when Compute North, the second largest hosting company at the time, filed for a Chapter 11 bankruptcy in September. Like many industrial scale miners, Compute North failed to hedge its power costs, and when the firm's power prices rose, Compute North's hosting contracts prevented it from passing this cost on to clients.

With margins effectively negative, Compute North was driven into technical default by its primary lender, Generate Capital. **Compute North owed nearly \$240 million at the time the bankruptcy began, but the beleaguered company covered all of its secured debt with collateral or via a 363 asset sale. Roughly \$40 million in unsecured debt still stands, while Compute North raised \$14.7 million in cash from the 363 sale that is yet to be divided up among creditors.**

Compute North 363 Asset Sale Proceeds vs. Liabilities



Source: Compute North Chapter 11 filings

The most coveted assets in Compute North’s sale – its mining facilities – ended up in the care of a handful of creditors.

Facility	New Owner	Capacity	Operationality
Kearney, Nebraska	Generate Capital	100 MW	Fully operational
Big Springs, Texas	Foundry	11 MW	Fully operational
North Sioux City, South Dakota	Foundry	6 MW	Fully operational
Granbury, Texas (Wolf Hollow)	Generate Capital	Up to 300 MW	Partially operational
McCamey, Texas (King Mountain)	US Data Group	Up to 280 MW	Partially operational
Corpus Christi, Texas (Bootstrap)	N/A	Up to 300 MW	In development
Minden, Nebraska	Foundry (tentatively)	Up to 35 MW	In development

Source: Compute North Chapter 11 filings

The second major bankruptcy came from the largest public miners by hashrate (and the largest hosting provider in North America), Core Scientific, which filed for Chapter 11 in December. Per bankruptcy filings, Compute North has **\$1,404,001,000 in assets and \$1,330,974,000 in total liabilities.**

We don’t currently know what route Core Scientific will take to restructure its business via Chapter 11. Assuming the company opts for a 363 or similar asset sale, we’ve heard through the grapevine that it may only sell its mining machines, not its facilities. This is only hear-say, though, and we’ll need to wait until additional filings to know for sure.

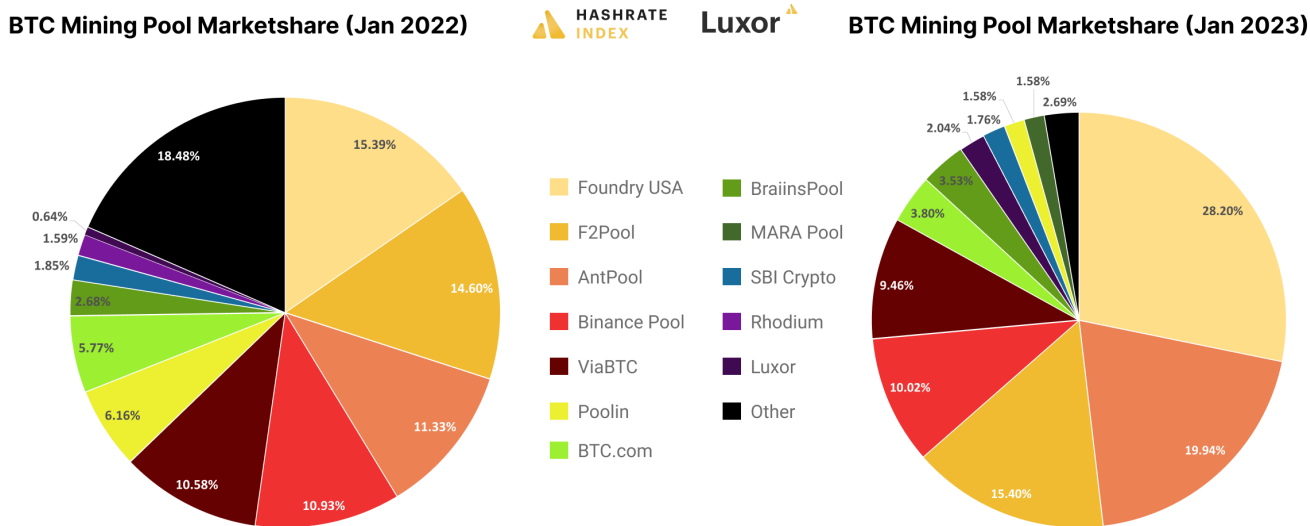


7

Mining pools consolidate in North America

As Bitcoin's mining sector continues to concentrate in North America, North American mining pools are attracting increasingly greater shares of hashrate.

North American mining pools accounted for 22% of total network hashrate at the end of 2021. Now, they account for just over 30% of Bitcoin's hashrate.



Source: Hashrate Index

2022 was also witness to the decline of Poolin. The erstwhile top-4 pool suspended withdrawals in September when it ran out of funds to cover its users. Mining pool balances were converted to IOUs which Poolin promised to pay out quarterly. The ensuing users exodus has pushed Poolin's share of hashrate down to 1.7%, a far cry away from the 12% share the pool enjoyed at its peak in 2022.

Poolin switched its payout method from FPPS to PPLNS as a result of its liquidity issues. The liquidity issues themselves partly stemmed from Poolin's hashrate token, which traders could purchase in exchange for an equivalent amount of hashrate to be paid out at a later date. An independent Singapore arbiter ruled that the IOUs Poolin issued for the BTC on client accounts is not valid, and that Poolin must pay back 88 BTC (~\$1.5 million) to one client



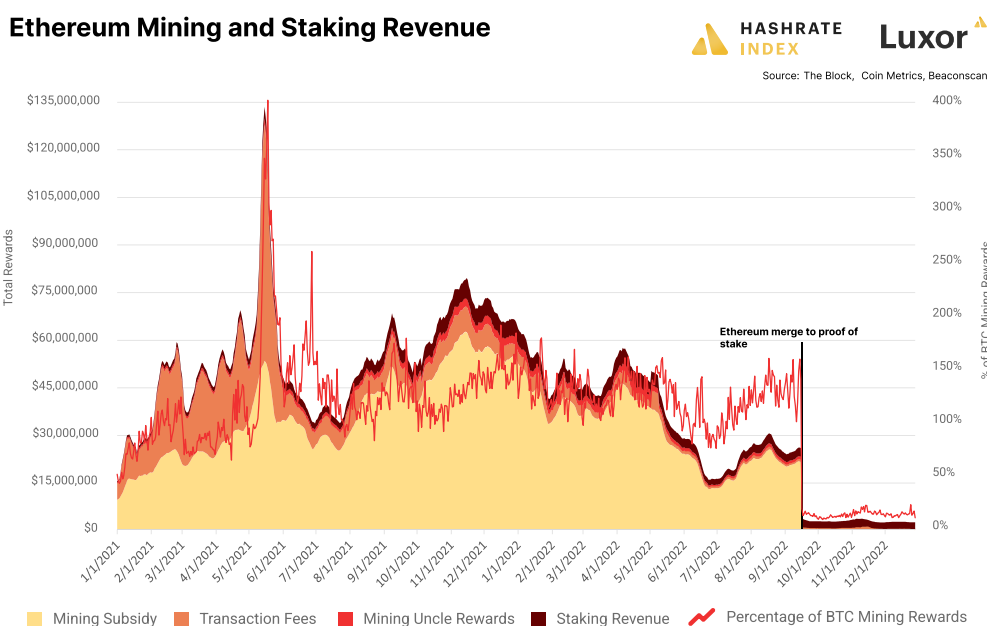
8

RIP GPU mining

2022 was the year where Bitcoin mining became the only proof-of-work game in town – or at least, the only one worth playing.

Ethereum completed its long-awaited merge to proof-of-stake in September, putting an end to the most lucrative proof-of-work mining opportunity of the last two years. **Even without three and a half months of mining revenue at the end of the year, Ethereum miners netted nearly as much revenue in 2022 as Bitcoin miners (\$8.87 billion vs \$9.55 billion).** Other proof-of-work blockchains earned miners a pittance by comparison.

After Ethereum merged to proof-of-stake, staking validator revenue is a shadow of mining revenue.



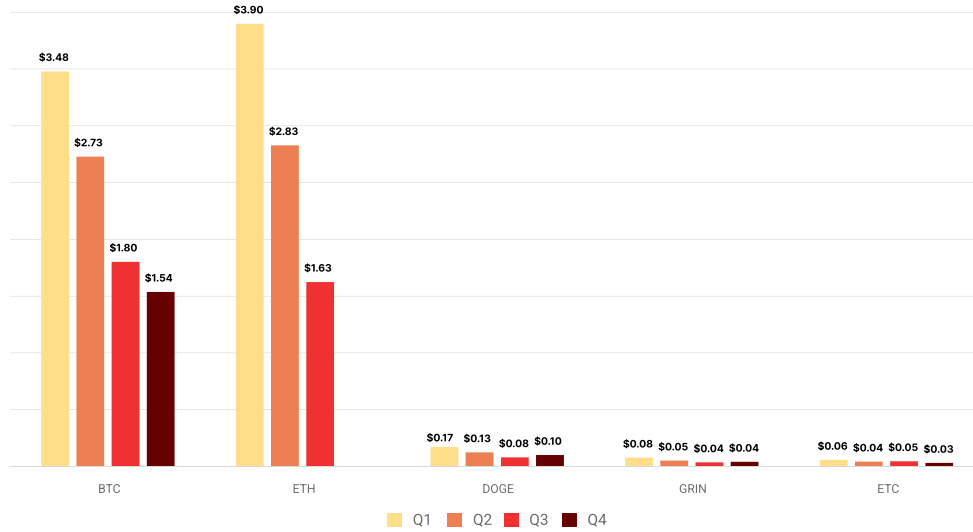
ETH miners had few viable options in a post-merge world. Most migrated to Ethereum Classic, Ravencoin, and Ergo, but these coins lacked the economic gravity to make the effort worth it (unless the miner had extremely low power costs).

Miners who couldn't turn a dime with these altcoins sold or scrapped their equipment, and some repurposed the rack space to mine Bitcoin. Interestingly, GPU prices have not fallen significantly since the merge. The average price for Nvidia's GeForce RTX 3090 on eBay, for example, had only fallen 9% from August to November 2022 (\$957 to \$871).

For the mega-miners like Hut 8 and Hive that mined ETH, they have repurposed these GPU farms (as much as they can) for other high performance computing.

With Ethereum mining dead in the water, Bitcoin became the only viable proof-of-work network on the market. Those with basically free power and/or low cost CPU/GPUs are the only miners who can profitably mine altcoins at this point, as evidenced by the paltry rewards these coins produced in 2022.

Mining Rewards 2022 (in BLN USD)





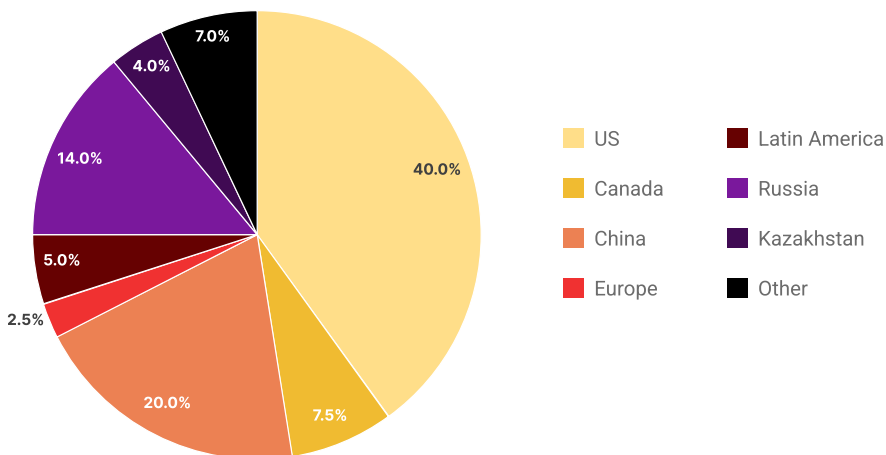
9

Mining around the world

So far, this report has mostly focused on the US and Canada. Still, we shouldn't forget that bitcoin mining is a globally distributed industry, with more than half of the hashrate generated outside of North America. In addition, some of the most exciting bitcoin mining trends and news come from places like Africa, Latin America, and the Middle East.

Therefore, we have dedicated this chapter to explaining what is happening in the bitcoin mining industry in countries outside of North America.

Global Hashrate Distribution



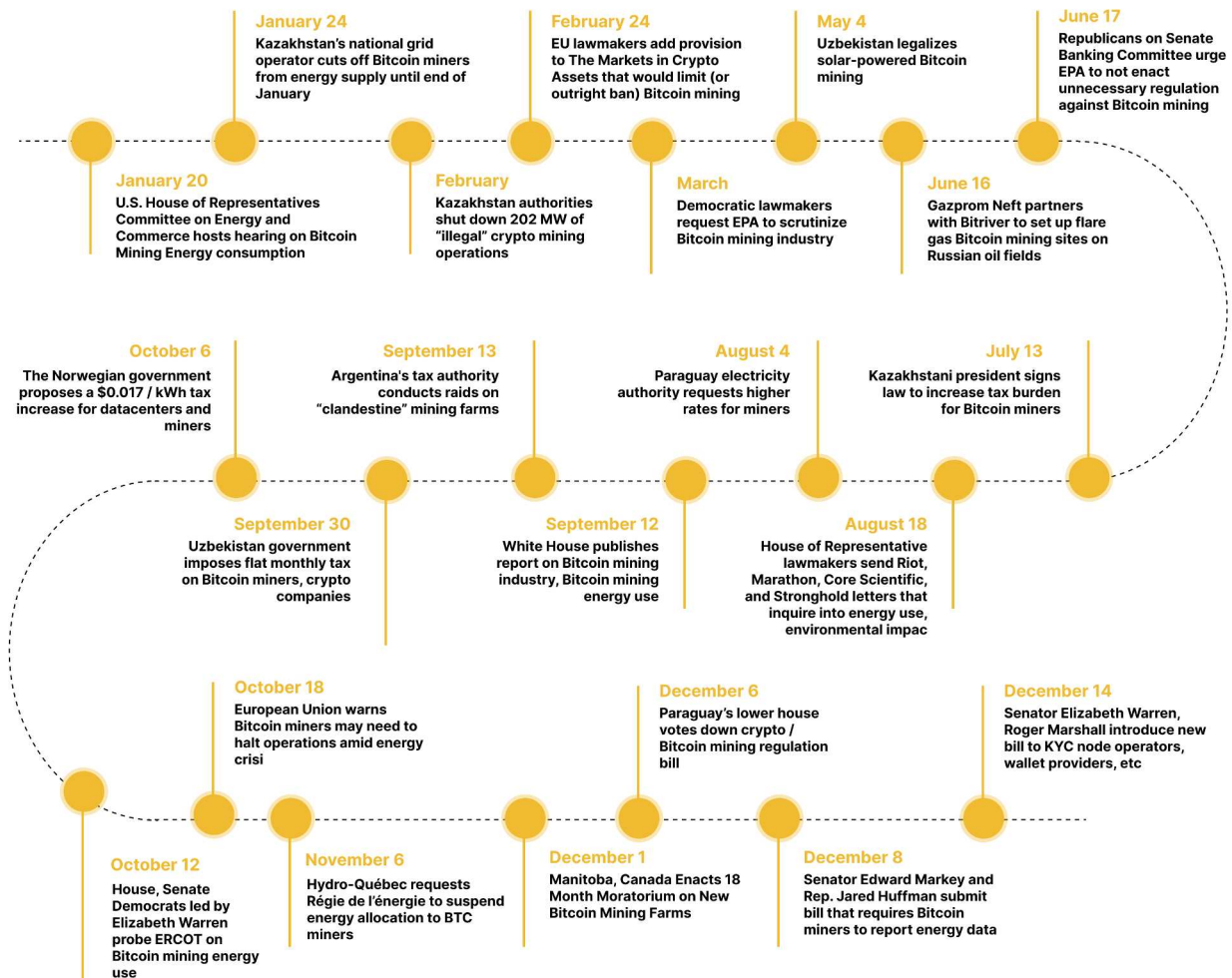
Best estimate based on internal Luxor business data

Source: Luxor

9.1 Governments turn up the regulatory and legislative heat

China's mining ban in 2021 was the most extreme political measure effected against Bitcoin miners. The measure led to a mass migration of China's Bitcoin mining industry across the globe, and this, in turn, has led to governments around the world reacting to the influx of Bitcoin mining business in their borders with regulations and legislations of their own – for better and for (most of the time) worse.

Indeed, headlines in 2022 were graced with news of government actions against the Bitcoin mining industry. We've highlighted the key ones below.



9.2 Europe

As explained thoroughly in chapter 3, Europe has been the center and source of a devastating energy crisis, marked by soaring electricity prices that have rendered bitcoin mining non-viable in most of the continent. The leftovers of the European bitcoin mining industry have sought refuge in the far north, where energy is abundant and transmission capacity scarce.

To illustrate how bitcoin mining is only feasible in specific, remote locations in Europe, we have created a chart showing the average electricity prices in 2022 in different European countries. As you can see, electricity prices in Central European countries like Germany, the Netherlands, and France are so elevated that anyone partaking in bitcoin mining there is throwing money out the window. For example, in France, the average electricity price in 2022 was \$275 per MWh, almost three times as high as the current break-even electricity price of the S19 Pro of \$92 per MWh.



Source: Nordpool, Hashrate Index, Daniel Jonsson (GreenBlocks)

However, some remote places in Europe’s far north still enjoy some of the lowest electricity prices on the planet. Thanks to stranded hydropower, the average electricity price in the north of Sweden and Norway was respectively only \$47 and \$18 per MWh in 2022. As we showed in chapter 3, stranded hydropower has also shielded miners in some North American regions from the worst electricity price inflation.

On the chart, we also see that inhabitants of the southern parts of Sweden and Norway don’t enjoy the same low electricity prices as their countrymen living further north. Historically, electricity has also been exceptionally cheap in southern Sweden and Norway, but newly expanded transmission capacity exposed these previously isolated regions to Europe’s energy crisis, and they suffered massive electricity price increases in 2022. This region was the home of many bitcoin miners, who have now been forced to migrate even further north to escape the surging electricity prices.

Electricity might still be cheap in northern Sweden and Norway, but a significant political risk exists, as politicians attempted to ban proof-of-work mining in the EU and Norway in 2022. So far, the industry has mostly prevailed against the political resistance.

Still, the Norwegian government recently introduced a full power tax for data centers, which was implemented in January 2023. The tax increased the all-in electricity rate by \$17 per MWh, effectively doubling the average 2022 spot price of \$18 per MWh. After accounting for transmission and distribution fees, northern Norwegian miners will have an all-in electricity rate of about \$50 per MWh, which is not exceptionally cheap, particularly considering the high Norwegian tax levels and labor costs.

European bitcoin miners have also found refuge in Iceland. The remote volcanic island has massive stranded hydro and geothermal capacity, historically making it a haven for energy-intensive industries like aluminum smelting. This stranded renewable energy supply has also attracted several international bitcoin mining firms, like Hive Blockchain, Genesis Digital Assets, and GreenBlocks.

Similar to northern Sweden and Norway, the remote geographical location of Iceland has protected it from the worst impacts of the energy crisis. Electricity prices are sufficiently low for bitcoin mining, but the industry has still slightly declined in 2022. The country's crypto mining industry has historically been dominated by traditional data center companies that now seem to pivot away from the activity. Still, as mentioned, fully-focused bitcoin mining firms exist in Iceland, and some are looking to ramp up capacity.

Although northern Sweden, Norway, and Iceland are the last refuges for bitcoin mining in Europe, we don't anticipate these regions to see a considerable hashrate increase in 2023. The market is starting to become saturated, with intense competition for grid connections. In addition, the governments of these countries don't seem to support mining activities, as they instead want the scarce electricity to go to other activities, including the massive electrification of the Norwegian offshore oil industry.

9.3 Latin America

Central and South America have become increasingly popular destinations for miners in a post-China mining ban world. The continent offers cheaper electricity than its neighbors to the North, though some regions face challenges with regard to social and political stability. In this vein, bribery is common in Latin America as a way to lower importation tariffs and to clear customs.

The most popular countries for mining in Latin America are Venezuela, Paraguay, and Argentina. Economically, socially, and politically, Venezuela is the most unstable country on the continent, so most miners in this country are natives, well-connected, and willing to take risks – or some combination of the three.

Flushed with abundant hydro, Paraguay is quickly growing as a Bitcoin mining hub. The Itaipu Dam – a hydroelectric marvel that is second only to China's Three Gorges Dam in terms of total electrical output – produces more power than Paraguay could ever hope to consume. Paraguay shares the dam with Brazil, and often sells the excess power it generates to the neighboring country. The dam's overproduction creates a prime opportunity for Bitcoin miners to soak up the excess. Regrettably, though, Paraguay's government shot down a bill that would have created a regulatory framework for Bitcoin mining and capped power tariffs for miners.

Regulation and legislation have also hamstrung mining developments in Argentina, with the Argentine tax authority conducting raids throughout the year against crypto miners. Argentina's government has also proposed an additional 4% tax on miners for 2023, as well.

All of that said, we expect Latin America's hashrate share to grow in 2023 and beyond as miners increasingly hunt for cheap electricity.

9.4 Russia and Kazakhstan

Russia and Kazakhstan have become some of the most popular countries for bitcoin miners thanks to their abundant supply of a diverse mix of stranded energy, including natural gas, coal, and hydro. According to Cambridge, in January 2022, Russia and Kazakhstan housed 5% and 13% of Bitcoin's hashrate. Since then, the bitcoin mining industry has grown in heavily energy-sanctioned Russia and shrunk in politically volatile Kazakhstan.

Let's start by looking at Russia, where the bitcoin mining industry is thriving. The country has for several years housed a substantial bitcoin mining capacity in Siberia, where massive, under-utilized hydropower plants from the Soviet era provide some of the cheapest electricity in the world.

However, in 2022, another mining hub appeared in the eastern part of the country, close to Moscow. Due to Russia's reduced natural gas exports following its invasion of Ukraine, it has vast excess supplies of natural gas to offload. The Russian government encourages residents and businesses to increase their natural gas consumption to prevent supplies from piling up. According to sources in the region, bitcoin miners are among those businesses that have significantly ramped up electricity consumption to take advantage of the cheap natural gas, with some even located behind the meter at natural gas power plants.

While the sanctions have led to a thriving environment for the country's domestic bitcoin miners, it has created enormous obstacles for western companies and individuals hosting machines at Russian mining facilities. Many machines are now stranded in the country due to sanctions (Compass Mining, for example, was unable to extract customer rigs that were marooned in one BitRiver's Russia facilities).

Bitcoin mining is also increasingly utilized as a flare mitigation technology in Russia. In June 2022, Gazpromneft, Russia's third-largest oil producer, announced a partnership with BitRiver. They aim to set up bitcoin mining data centers directly at new oil fields in remote locations and use the previously flared natural gas for bitcoin mining. Russia is the biggest natural gas flarer in the world.

After seeing significant growth in 2022, the Deputy Minister of Energy in Russia estimates that the bitcoin mining industry consumes around 2% of the country's electricity, which equals around 1.7 GW. The same minister estimated that the industry consumed around 1.3 GW in 2021, meaning the Russian industry grew by about 30% in 2022.

In neighboring Kazakhstan, however, things are looking bleaker for bitcoin miners. The industry grew massively in 2021 as both domestic and Chinese firms set up shop at a record pace following China's ban. Unfortunately, this rapid expansion contributed to strains on the country's out-of-date electricity grid, and the government soon started cracking down on the industry.

There is an ongoing debate between different governmental entities on how to regulate Bitcoin mining, and its future is highly uncertain from a regulatory perspective. What we know is that a new electricity tax will be introduced in 2023, which will significantly increase the all-in electricity rates of all operations.

Kazakh miners have faced a variety of obstacles in 2022, including electricity rationing, internet shutdowns, increased power taxes, new and ever-changing reporting requirements, license requirements, and more. This Kafkaesque bureaucratic mess has reduced what was just one year ago a proud stronghold of bitcoin miners to a shadow of its former self. Most estimates we have come across put Kazakhstan's bitcoin mining industry at less than 500 MW now, far below its 1.5 - 2 GW one year ago.

With its vast stranded energy resources, Russia will likely continue attracting bitcoin miners in 2023. The country is working on a regulatory framework, and it seems to recognize the opportunity of exporting its excess energy through the internet via mining. Meanwhile, miners in Kazakhstan will likely continue facing bureaucratic obstacles, but things could improve if the government implements more stable regulations.

9.5 Asia

When China banned Bitcoin mining in 2021, many thought the prohibition meant lights out for the country, but China still persists as the dominant hub for Bitcoin mining in Asia, and it's the reason why the Asian continent itself is second only to North America regarding the amount of hashrate it houses.

In China, only the politically connected have the privilege to operate a Bitcoin mining farm. Most of these farms are smaller (e.g., 2-5 MW), and for those that host, the hosting rate can be prohibitively high (e.g. \$0.085/kWh). Notably, since the ban, some bitcoin miners have pivoted to mining altcoins in a bid for quicker ROI, though 2022's bear market rout against altcoins have made this less-and-less feasible.

One of the biggest obstacles miners face in the region is a ban on the importation of mining rigs. After China's mining ban, Chinese mining rig manufacturers outsourced fabrication to Malaysia, Thailand, and Taiwan, and importing new ASICs from these countries is difficult-to-impossible. Rather than risk it, Chinese miners would rather send newly purchased rigs to a country where Bitcoin mining is legal.

In Asia, these jurisdictions include Indonesia and Laos, though the amount of hashrate concentrated in these countries is still very small relative to the rest of the network. Mongolia has become a popular jurisdiction after China's mining ban, though many miners sent mid-gen machines to this region which are now unprofitable at most power rates given current hashprice.

In the near future, we expect China's hashrate growth to plateau in the best case and to decrease in the worst case. Reason being, Chinese miners aren't able to import new mining rigs, and this will naturally cap hashrate growth.

9.6 The Middle East

The Middle East consists of countries on the Arabian Peninsula, Iran, and the northeastern parts of Africa. With a seemingly endless supply of oil and gas, it is one of the most energy-dense regions on the planet. Certain countries in the region aim to attract new technological industries, primarily building up energy refining industries. These factors could make the region a future bitcoin mining hub.

Although the future potential is enormous, The Middle East currently generates little hashrate. Iran has historically been the region's leading hashrate producer, and at one point, Cambridge University's Centre for Alternative Finance estimated that the country generated almost 5% of Bitcoin's hashrate. This number shrunk to only 0.1% in January 2022 due to unfavorable regulations and sociopolitical instability. Iran's bitcoin mining industry kept facing headwinds in 2022 as continuous electricity shortages forced the government to order the shutdown of facilities.

While the industry is shrinking in Iran, things are looking brighter on the Arabian Peninsula, with growth in countries like Saudi Arabia, the United Arab Emirates, and Oman. Historically, the scorching heat in this desert region has made it challenging to sufficiently cool mining rigs, but with the advent of immersion cooling, the heat is now a manageable problem.

The region's potential was confirmed in June 2022, when the flared natural gas bitcoin miner Crusoe Energy raised \$350 million from, among others, the Abu Dhabi sovereign wealth fund and the Oman sovereign wealth fund. As part of the agreement, Crusoe Energy has set up offices in Oman and Abu Dhabi and will utilize bitcoin mining as a flare mitigation technology in the Middle East.

Countries on the Arabic Peninsula will likely keep attracting hashrate in the coming years as they eagerly seek to build new refining industries for their enormous energy resources. These stable countries with low political risk haven't shown any particular hostility toward Bitcoin or mining, and could be a viable destination for western companies looking to diversify their operations geographically.

9.7 Africa

Africa is something of a darkhorse in the Bitcoin mining industry.

The continent's mining sector is still very small relative to other continents (the largest mine we know of, for example, is BigBlock's 5 MW facility in Congo). But this largely underdeveloped continent has plenty of untapped promise in the form of hydro power.

BigBlock's facility runs on hydro, as does the Kenyan based Gridless, which raised \$2 million from Jack Dorsey's Block in Q4 of 2022.

Africa features a wealth of underutilized hydro power; in essence, many African countries produce more power from hydroelectricity than their populace can utilize, and the same goes for geo-thermal power. Bitcoin mining is the perfect energy sponge for this excess electricity.

Ethiopia produces the most hydro power in Africa, followed by Angola, South Africa, Egypt, Congo, and Mozambique. Given Angola's wealth of hydropower, we have heard of many Chinese miners moving to the region or at the least considering it.

Africa: 2021 Hydropower installed capacity (MW) by country

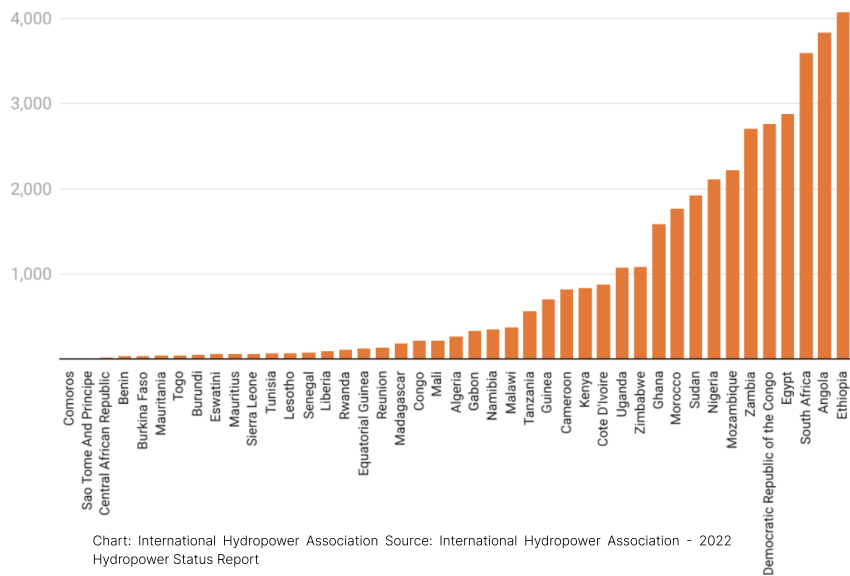


Chart: International Hydropower Association Source: International Hydropower Association - 2022 Hydropower Status Report

We anticipate that Africa's hashrate share will continue to grow as opportunities in other more established hubs dry up and miners and investors search for opportunities in fledgling sectors.



10

Projections for 2023

2022 was perhaps the toughest year for Bitcoin miners in the ASIC era, but 2023 could pan out to be tougher yet if market conditions don't improve. In this chapter, we provide 10 bitcoin mining predictions for 2023.

Bitcoin's hashrate growth will slow down

2022 confirmed what we have seen during several cycles historically: hashrate follows bitcoin's price with a lag of several months, as it takes time to manufacture mining rigs and build sites.

We will most likely see hashrate growth slow down in 2023, as the poor mining economics of 2022 didn't incentivize capacity expansion. The hashrate that does come online in 2023 will mostly be delayed capacity miners initially planned to add in 2022. This delayed capacity will come online during the first half of 2023. After that, hashrate will stop growing and perhaps even contract, depending on bitcoin's price.

The number of public miners will decline

Public miners have better access to capital than private ones, particularly during bull markets. Still, being public also comes with several disadvantages. Arguably, the most significant burden of being a public company is strict reporting requirements that can be difficult and expensive to comply with.

After a devastating bear market, many public miners have been degraded to penny stocks with market caps below \$50 million, and these valuations don't exactly justify spending millions of dollars on annual reporting. These companies could drastically reduce administrative costs by going private. Some public miners will not go private but instead merge with other companies to share administrative costs and leverage economies of scale.

Hosting prices will fall

As we showed in chapter 3 section 6, hosting rates ballooned in 2022, due to rising energy prices and a lack of hosting supply compared to the rising demand.

We don't know if energy prices will fall, but we are confident that the hosting supply will significantly increase. As new build-outs finally come online, hosting providers will compete for clients in a much more adverse market environment. Moreover, as we explained in chapter 3 section 5, many miners higher up the cost ladder are already operating at neutral or negative margins.

Given the abysmal state of mining economics and the influx of competition, hosting providers will need to lower their costs to remain competitive in 2023. Those hosts who can't or haven't negotiated low enough power rates to maintain their own margins will struggle in 2023's adverse market environment.

Cost minimization will be essential in 2023

As we showed in chapter 3 section 5, the profit margin of bitcoin mining has become so slim that miners are heavily incentivized to reduce costs. Therefore, in 2023, miners will do their best to lower operational expenses.

Electricity is the most significant part of a miner's operational cost structure and will naturally be the top priority to minimize. Miners can lower their electricity costs by setting up operations close to stranded energy sources, helping to balance the grid, or selling excess heat. This bear market will force miners to become more sophisticated with regards to how they consume electricity.

In addition to lowering their all-in electricity prices, miners will attempt to get more hashrate per unit of electricity consumed by improving the efficiency of their mining rigs. The miners with good access to capital will switch their older machines to newer models like the Antminer S19 XP. Others will underclock machines to improve efficiency.

While electricity is the most crucial cost component to minimize in the long term, lowering administrative costs is the most obvious place to start for cost minimization in the bitcoin mining industry. Many bitcoin miners, particularly the public ones, have seen their administrative costs explode over the past two years as the rapid growth during the bull market didn't lend itself toward prudence. These companies will now be forced to lower executive compensation and other administrative expenses.

ASICs will become dirt cheap

ASIC prices are low compared to where they were at the peak of 2021 or even at the beginning of 2022. But they are not low enough, and in 2023, they will go lower.

As we showed in chapter 4, even at current depressed ASIC prices, an S19j Pro hashing at \$0.06 per kWh would take 925 days to ROI. That's a long payback period for a bitcoin mining machine that most likely only will remain competitive at that electricity rate for another 3-4 years.

In addition, we are seeing an influx of ASIC supply from distressed and bankrupt companies that are forced to sell. The latent ASIC supply that could be released on the market is so large that it could potentially lead latest generation ASIC prices to drop below \$8 per TH.

Miners will struggle to achieve sufficient up-time

This year we have seen substantial hashrate volatility as American miners have adjusted the uptime of their machines based on rapidly fluctuating electricity prices. Hashrate first dropped substantially during the summer, as heat waves in the United States led to soaring electricity prices that forced many miners to turn off their machines. The same thing happened in December but was caused by freezing weather, not a heat wave.

In addition, as we showed in chapter 3, electricity prices are relatively high in most markets globally. Some miners operating in electricity grids with relatively high prices will likely be forced to turn off their machines more often than they wish, thereby reducing their bitcoin production per EH/s. For those following bitcoin mining stocks, the comparative analysis of bitcoin produced per EH/s will become increasingly relevant.

Regulators will keep targeting bitcoin mining

As we showed in chapter 8, the regulatory pressure on the bitcoin mining industry grew in 2022. Some US states and Canadian provinces enacted various moratoriums on bitcoin mining to prevent the industry from gaining a foothold. On the US federal level, we saw some politicians engaging in saber-rattling against bitcoin miners, but most regulatory attacks happened on the state level.

We will likely continue seeing certain US states and Canadian provinces imposing new mining bans. Regulators in one state will learn from their colleagues in other states, meaning that the current mining bans in certain states and provinces could spread to other jurisdictions. A common factor among the US states that have enacted mining moratoriums is that they are governed by Democrats.

It's unlikely we will see any new regulation on the federal level in the US and Canada in 2023.

Miners will work on strengthening their balance sheets

2023 will be a year of restructuring in the bitcoin mining industry. Many companies, especially some of the public ones, have dangerously high levels of debt relative to equity and exceptionally high debt service payments relative to operating cash flows.

The unsustainable debt levels of some companies leave debt restructuring as their only option. Debt restructuring can mean negotiating lower interest rates or extending the due dates of the debt. If the financial situation of the company is particularly bad, the debt can be turned into equity. Many bitcoin miners are in such a poor financial state that this is their only option other than bankruptcy. Core Scientific is an example of a miner going this route before they filed for Chapter 11.

Another way to strengthen a balance sheet is simply selling assets and using the proceeds to pay down debt. Argo recently undertook this procedure, selling its flagship mining facility to reduce debt.

Strengthening balance sheets will be a top priority for bitcoin miners in 2023 as they fight to avoid bankruptcy.

Miners will increasingly utilize bitcoin mining derivatives

2022 proved how critical risk management is for bitcoin miners. Except during the peaks of the bull markets, bitcoin mining is an ultra-competitive, low-margin business. This means that protecting cash flows is exceptionally important for the long-term success of a bitcoin mining operation.

After the traumatic bear market of 2022, miners will become more sophisticated with risk management in 2023. A proper risk management strategy is holistic and consists of optimizing the treasury as well as hedging revenues and costs with derivatives. Until recently, miners could hedge most treasury and cost components but not revenue.

This changed in late 2022 when Luxor launched its hashprice non-deliverable forward contract, which allows miners to sell their hashrate for a specific hashprice.

In 2023, we will see more miners seeking to hedge anything and everything that can be hedged, just like what is expected in more mature commodity-producing industries.

The bitcoin bear market will come to an end

Bitcoin has historically gone through some remarkably similar bull and bear cycles. It can be helpful to compare the current bear market to previous ones to estimate how bad the current one could get and how long it could last. As Arcane Research points out in its 2022 year-end report, bitcoin's current bear market has lasted for 376 days, a length comparable to the bear markets of 2014-15 and 2018.

The current peak-to-trough drawdown of 78% is also not far from the maximum drawdowns of 2015 and 2018 of 85% and 84%, respectively. Judging by historical cycles, the current bear market looks like it will soon end.

Although the bear market could end in 2023, it is still too early for another full-scale bull market to commence. Bitcoin price growth is primarily driven by new capital flowing into the space. In 2023, we will likely see few outsiders starting to allocate capital to crypto and bitcoin, as the extreme market chaos and outright scams of 2022 have scared many away from the sector.

It will take time before traditional finance firms are ready to build bitcoin exposure, and we will likely have to wait patiently for an additional one or two years before market participants are prepared to embark on the next bull cycle.