



**HASHRATE
INDEX**

Hashrate Index

Q2-2023 Report: A Bridge Over Troubled Water

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About Hashrate Index

[Hashrate Index](#) is a Bitcoin mining data, analytics and research platform. Our platform offers novel data sets that enable miners, traders, content creators, and investors to gain key insights into the mining industry to generate alpha. Hashrate Index is a product of [Luxor Technologies](#), a Bitcoin mining software and services company.

1 Executive summary: Coming up for air

2 Hashrate, difficulty, and hashprice

- a. Hashrate slows, difficulty grows
- b. Hashprice sprints then trips
- c. Block Subsidy and Halvings

3 Ordinals and Inscriptions: How miners learned to stop fighting and love the jpeg

- a. Inscriptions, ordinals send transaction fees to multi year highs
- b. Inscription blockspace dynamics

4 ASIC price stabilize

- a. S19 XP, next-gen premiums rise
- b. New rigs and hydro and immersion models
- c. Rigs to come in 2024 and 3nm chips

5 Electricity markets take a chill pill

- a. Natural gas prices are normalizing
- b. US power prices come down from record highs
- c. An analysis of summer curtailments in Texas
- d. US hosting rates stabilize with power markets

6 Public Bitcoin miners bounce back

- a. Public Bitcoin miners are selling more BTC
- b. Public Bitcoin miner marginal cost of production
- c. Public Bitcoin miner hashrate expansion
- d. Don't drink the kool-(AI)d

7 Bitcoin mining around the world

- a. United States
- b. Canada
- c. Latin America and Paraguay
- d. Russia
- e. Kazakhstan
- f. The Nordics
- g. The Middle East
- h. Asia

8 Final Word: 2024 halving and hopium



1

Executive Summary: Coming up for air

It's been over two years since China's Bitcoin mining ban and the Great Hashrate Migration, and the Bitcoin mining landscape has changed indelibly since the CCP shoed the bulk of the industry from its shores.

Since the historic event, miners counted their luck through a brief "hashprice super cycle" as mining profitability surged directly after the ban, then a hashprice stupor cycle as profitability sagged in the 2022 bear market. When Bitcoin hit \$15k in November last year, few commentators could conceptualize a \$30k Bitcoin price by 2023's halfway point. But Bitcoin loves to screw with expectations.

Two years removed from China's ban and Bitcoin's mining industry has matured considerably. No doubt, mining business in 2023 can be low profile, scrappy, and fly by night, but the shadow play days of Bitcoin mining – where the ins and outs of the Bitcoin mining industry were largely opaque and operators try to – are over.

Now, a more buttoned-up coterie of miners, public and private, dominate the landscape, particularly in the North American sector where Bitcoin mining has blossomed following the washout in China. We've seen hashrate spillover into new mining hubs outside the US, as well, including Russia, the Middle East, Latin America, and Southeast Asia. And to be clear, there is still plenty of mining going on in China – but the scales are more balanced globally than they ever have been.

As the industry matures from its stumbling infancy, miners are internalizing hard lessons from 2022's market chaos. They are engaging in more responsible treasury management and financing practices, and formerly bankrupt miners are emerging from restructurings with sounder operational strategies.

2022 shook up Bitcoin's mining market, positioning on-the-ball operators for success this year. As we approach and surpass the 2024 Bitcoin Halving, we anticipate more shake ups still. Cheap energy is the name of the game and at the top of mind for miners right now, followed by ASIC procurement and treasury management.

Anything they can do to cut costs in the above areas and elsewhere will be key for navigating the Halving. For some lucky miners, this will come from negotiating lower power rates, especially those miners big enough to participate in demand response programs. Others will drive down power bills by underclocking their machines with firmware. Some will look for cheaper hardware and cut down on logistics costs. A small few still might find ways to recycle waste heat to reduce their bottom line. For the bigger miners, cutting administrative costs will also be critical.

If it ever was, Bitcoin mining isn't a plug-in-and-let-her-rip game anymore. The operators who survive the halving will have access to the cheapest power and/or have effective expansion and operational strategies to lower CAPEX/OPEX. When the axis of mining shifted from the East to the West following China's ban, it became easier than ever for North American investors to enter the industry, and new interest and capital flooded into the space at an unprecedented rate. Some of the more pedestrian investors, particularly retail with low MOQ hosting deals, could have trouble in the year to come.

As the industry continues to grow and become intertwined with institutional finance, we expect the trend of consolidation that began in 2021 and accelerated in 2023 to continue. At the same time, Bitcoin's hashrate has never had a larger global footprint, and we anticipate that Bitcoin's hashrate will continue to spread out across the globe and become increasingly geographically dispersed.

Miners in North America need to remember that they are not competing just with their neighbors, but also the burgeoning mining industry in the Middle East and the remaining industry in China and the growing industry in Russia and Latin America and elsewhere.

Each region and context has its own advantages and disadvantages, and some forward-thinking miners with connections and resources have started diversifying their hashrate across different jurisdictions.

In Q2, we saw many miners capitalizing on low ASIC prices for ongoing or future laying expansions. Bitcoin's rally and the reprieve it gave to hashprice (with more than enough help from inscriptions and ordinals) gave miners a chance to pause and breathe after 2022's hashprice constriction choked their margins. The lifeline was especially welcomed for middle-and-high cost miners who found themselves unprofitable for much of Q4-2022.

Now, with Q2 in the books, Bitcoin's price waning and hashrate on the rise, miners are bracing for what could be a brutal fourth Halving epoch. Building on a trend from last year, mergers and acquisition, consolidation, and distressed asset sales are accelerating in 2023 as poorly positioned miners look for an exit and well-positioned miners look for favorable opportunities to expand in preparation of the event. We expect the halving to accelerate these trends.

But for the rest of 2023, with Q2's hashprice reprieve running out of steam and the Halving less than eight months out, the mantra for miners is simple: survive and prepare.

2

Hashrate, difficulty, and hashprice

**Q2-2023
Average**

\$77.02/PH/day
0.00275 BTC/PH/day

**Q1-2023
Average**

\$73.08/PH/day
0.00324 BTC/PH/day

**Q2-2023
Low**

\$61.01/PH/day
0.00248 BTC/PH/day

**Q1-2023
Low**

\$59.42/PH/day
0.00346 BTC/PH/day

**Q1-2023
High**

\$121.64/PH/day
0.00433 BTC/PH/day

**Q1-2023
High**

\$83.73/PH/day
0.00375 BTC/PH/day

Hashrate slows, difficulty grows

2023 has been a big year for Bitcoin's hashrate growth. Though it didn't increase as much as miners expected, hashrate grew more in 2022 than 2021 (the year of the China Mining Ban), and now it's looking like 2023 will see more hashrate growth than last year.

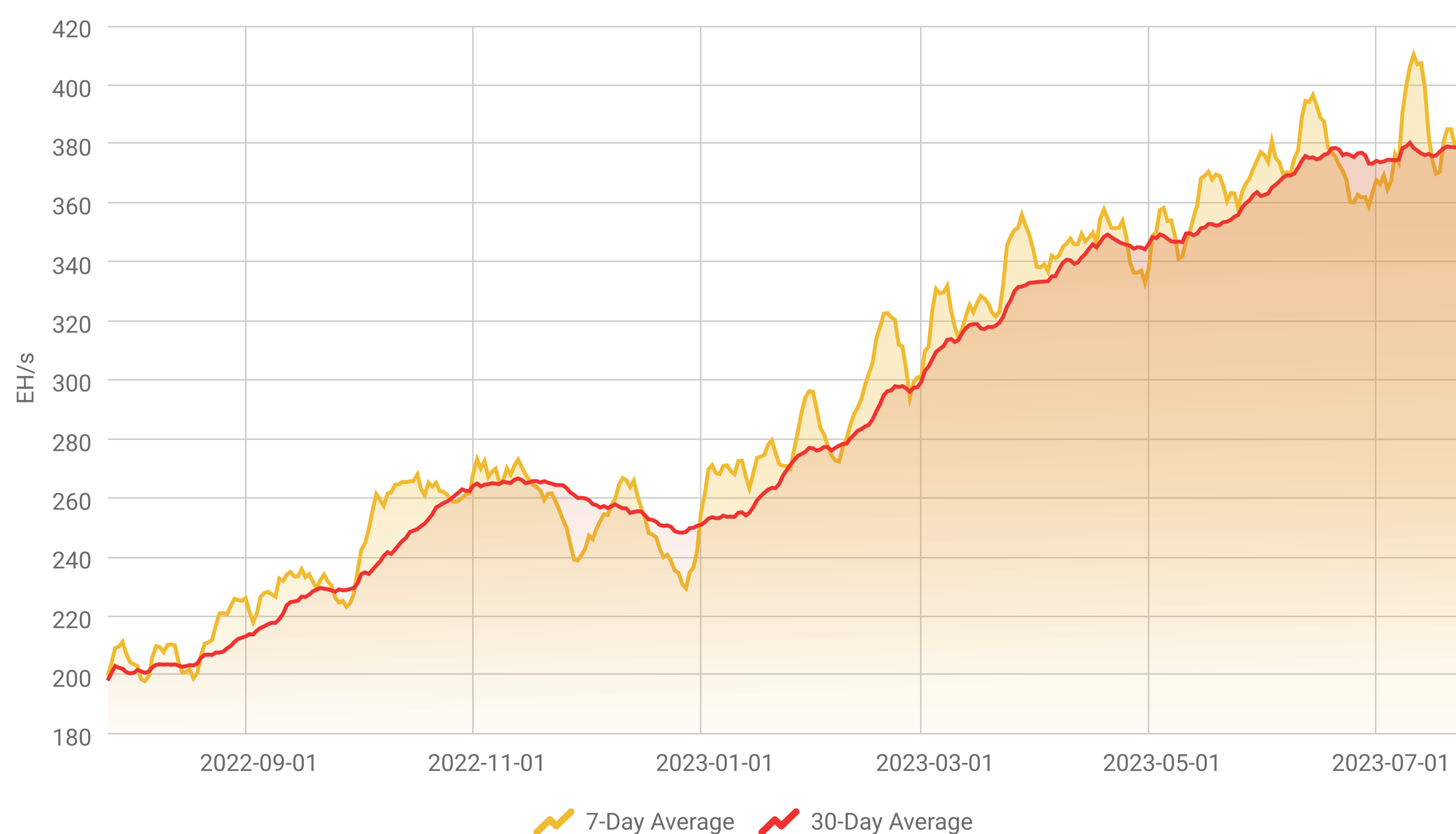
This growth slowed in Q2, though, demonstrating for the second year in a row a new secondary effect of the Great Hashrate Migration.

To that point, North America's high concentration of hashrate (45-50%) means a new type of seasonality for Bitcoin's hashrate: summer heatwaves have been stressing regional grids across the US and forcing miners to curtail, curbing hashrate as a result. **Case and point, Bitcoin's 7-day average hashrate grew 7.5% over the course of Q2-2023, a much more modest growth than Q1's 35% growth.** The sluggish growth is largely due to summer temperatures interfering with operations in mining hotspots like the US and particularly, Texas, though it's worth noting that this summer has not hamstring hashrate growth as much as last year's record heatwaves.

The summer aside, Bitcoin's hashrate has grown tremendously thus far in 2023. Year-to-date (as of July 22, 2023), Bitcoin's hashrate has grown 50% from 255 EH/s to 380 EH/s.

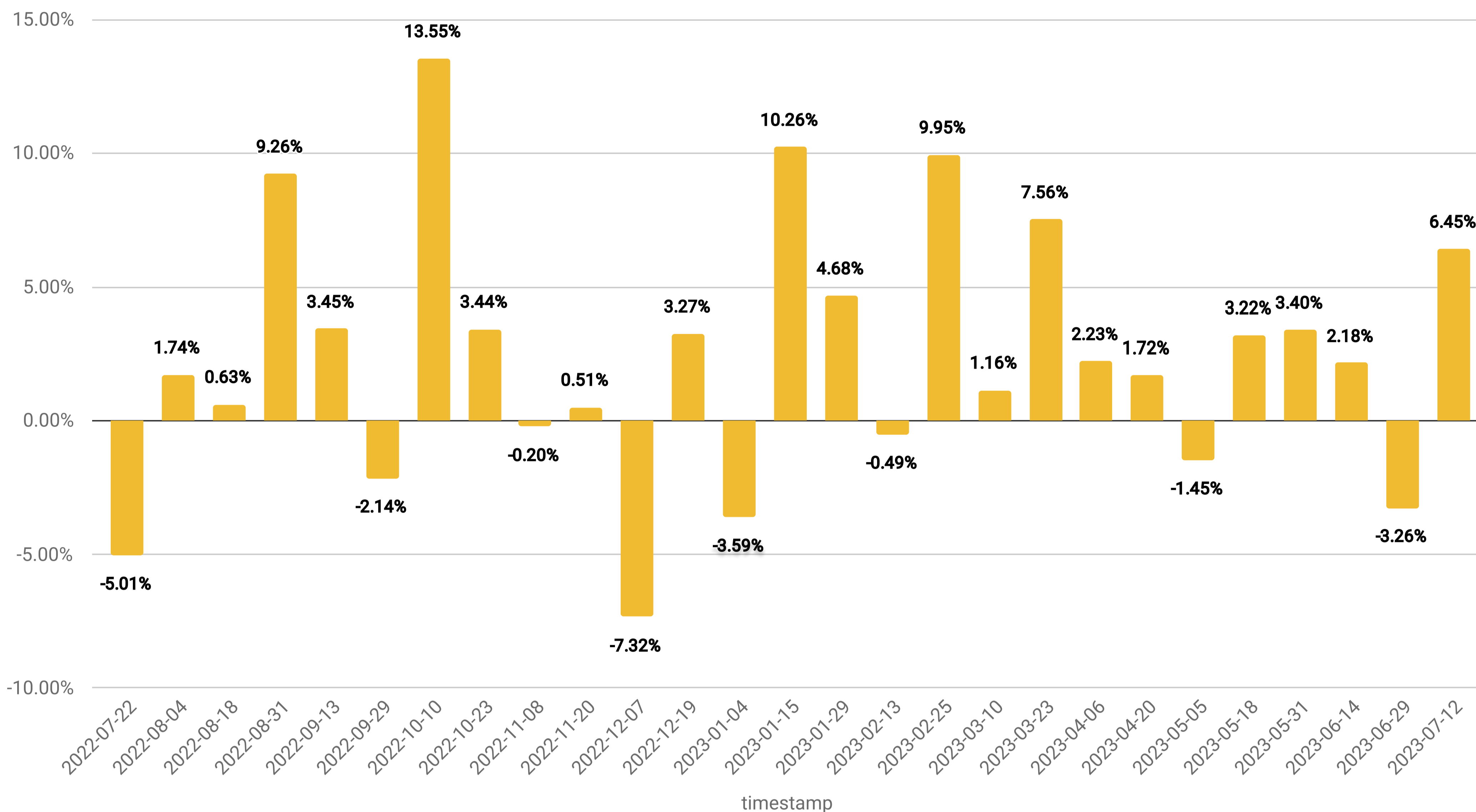
Bitcoin Hashrate 7-Day and 30-Day Average

HASHRATE INDEX Luxor



In step with Bitcoin's hashrate, Bitcoin's difficulty has grown 8.1% over the Q2-2023 and 52.5% year-to-date (as of July 22, 2023).

Bitcoin Mining Difficulty Percentage Change



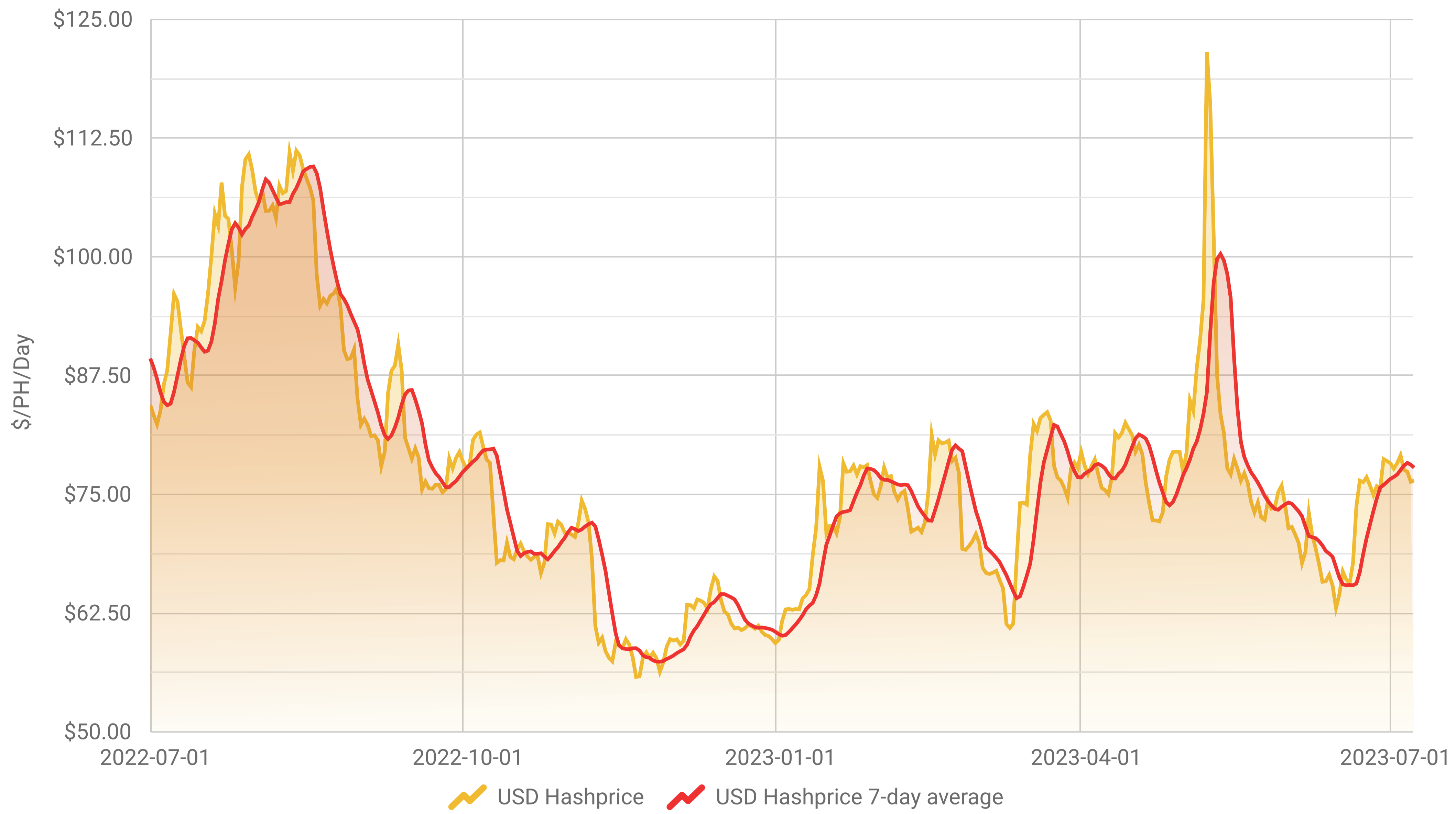
As we type these words, Bitcoin's difficulty just fell 2.94% from its all-time high of 53.91T. Last summer, Bitcoin miners were graced by three straight negative difficulty adjustments from June 22 to July 21 as heat waves roasted the US and took hashrate offline. So far this year, miners have largely duck the blistering weather, and the heat has not interfered with hashrate as much. But as we enter August, historically the second hottest month of the year in the US, we could see more negative difficulty adjustments if the weather gets gnarly enough, though any disruptions could easily be offset by expansion in other mining sites around the world.

Hashprice sprints then trips

As some of y'all may recall from our 2022 End of Year Report (and if you're a miner, you don't need reminding), hashprice was deep in the gutter in Q4 of last year. It reversed course somewhat in Q1 to give miners some reprieve, and in Q2, it bounced back hard and stabilized thanks to a combination of NFT degeneracy (which we explore further in our section on Ordinals/Inscriptions), Bitcoin's price resuscitation, and sluggish hashrate growth.

Q2's average USD hashprice was \$77/PH/day, a 5% increase from Q1's \$72/PH/day average and a 30% increase from Q4's \$59/PH/day average. Q2's average BTC hashprice was 0.00275 BTC/PH/day, a 15% decrease from Q1's average.

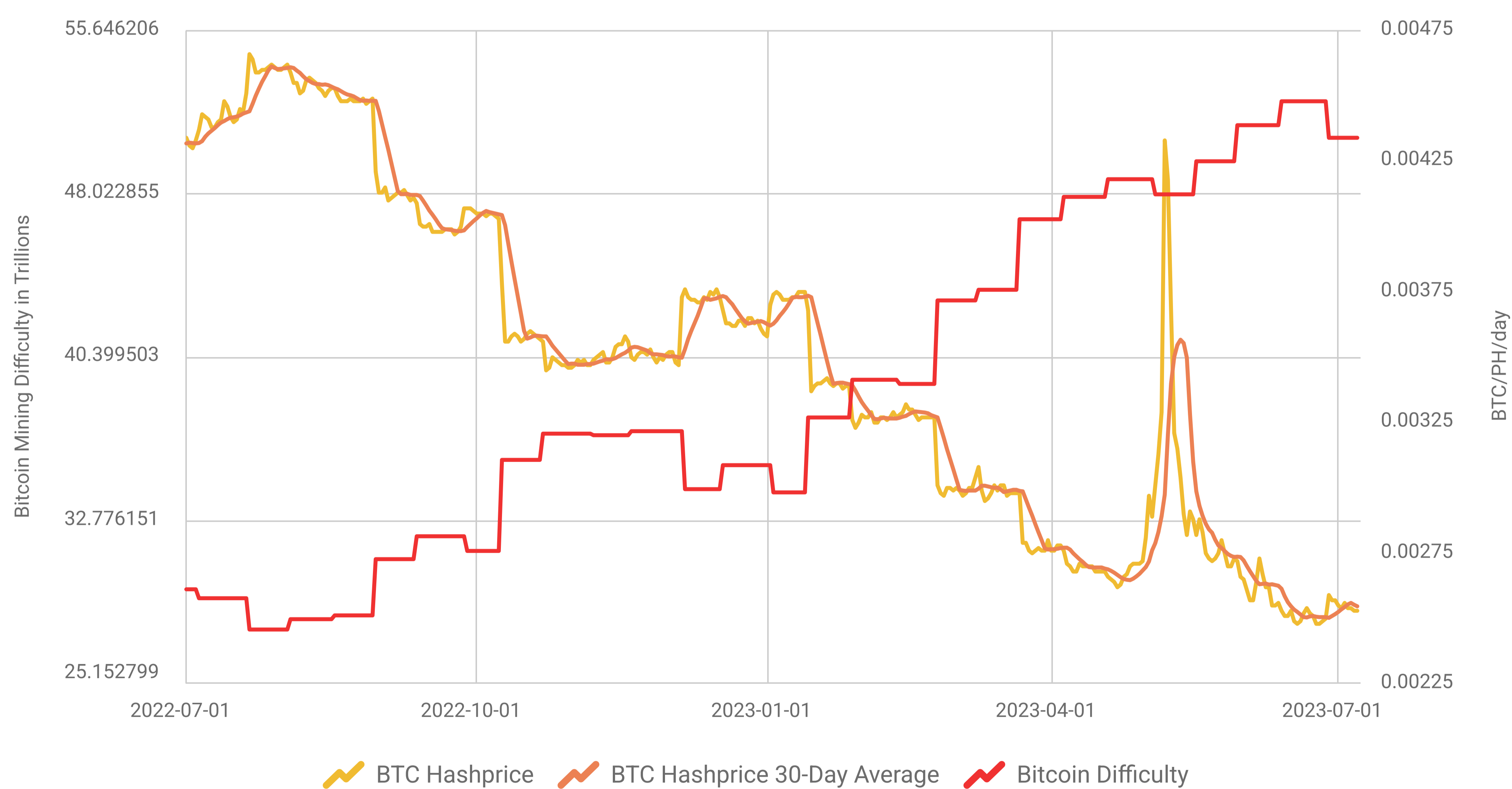
USD Hashprice Daily Average and 7-day Average



All things considered, Q2 was a relative feast for profit starved miners. When you consider that an s19j Pro's breakeven at \$0.07/KWh power is \$51.25/PH/day, you can imagine how many miners, particularly in the North American context, were sweating at the end of 2022. Q1 offered minor relief from this margin squeeze, and Q2 relaxed it further.

Still, with Bitcoin's rally stalling and difficulty hitting an all-time high in July, the pressure is back on hashprice, which is \$72/PH/day and 0.00244 BTC/PH/day at the time of writing.

BTC Hashprice vs. Bitcoin Mining Difficulty





3

Ordinals and Inscriptions: How miners learned to stop fighting and love the jpeg

2023 is reminding bitcoin miners that transaction fees can make a huge impact on their bottom line – and they partly have monkey and Pepe jpegs to thank for that.

In 2022, transaction fees accounted for 1.63% of all block rewards. Compare that to 4.9% year-to-date, 2.3% in Q1-2023, and 8.11% in Q3-2023. The boost isn't coming from traditional economic transactions; it's coming from a new way to mint and trade NFTs on Bitcoin.

Inscriptions, as they are called, are digital images, videos, text, video game files (yes, really) – any arbitrary data that Bitcoin users can include in a Bitcoin transaction using specific transaction conditions. Unlike other NFTs on Ethereum, Solana, and other chains, these NFTs are actually uploaded on-chain. To track them, collectors use Ordinal Theory, the mathematics of sequencing, to mark a single satoshi in each transaction to acts as the “deed” to the inscription. The Ordinal Theory traces each satoshi from the Genesis block based on a first-in-first-out basis.

As with paper currency and coinage, where collectors seek out rare mints and coins with numismatic value, ordinals have sparked a market for so-called “rare satoshis.”

And the interest in inscriptions and ordinals more broadly ignited a firestorm of transaction activity on Bitcoin's blockchain in Q2 –so much so, that transaction fees hit their highest levels since October 2020.

| Rarity Tier | Description | Total Supply |
|-------------|---|-----------------|
| Common | Any sat that is not the first sat in a block | 2.1 quadrillion |
| Uncommon | The first sat of a block | 6,929,999 |
| Rare | The first sat of the first block in a new difficulty epoch | 3,437 |
| Epic | The first sat in the first block after a halving event | 32 |
| Legendary | The first sat in the first block after a coinciding halving event and difficulty adjustment | 5 |
| Mythic | The first sat in the Genesis Block | 1 |

The rare satoshi taxonomy, according to inscription / ordinals creator Casey Rodarmor

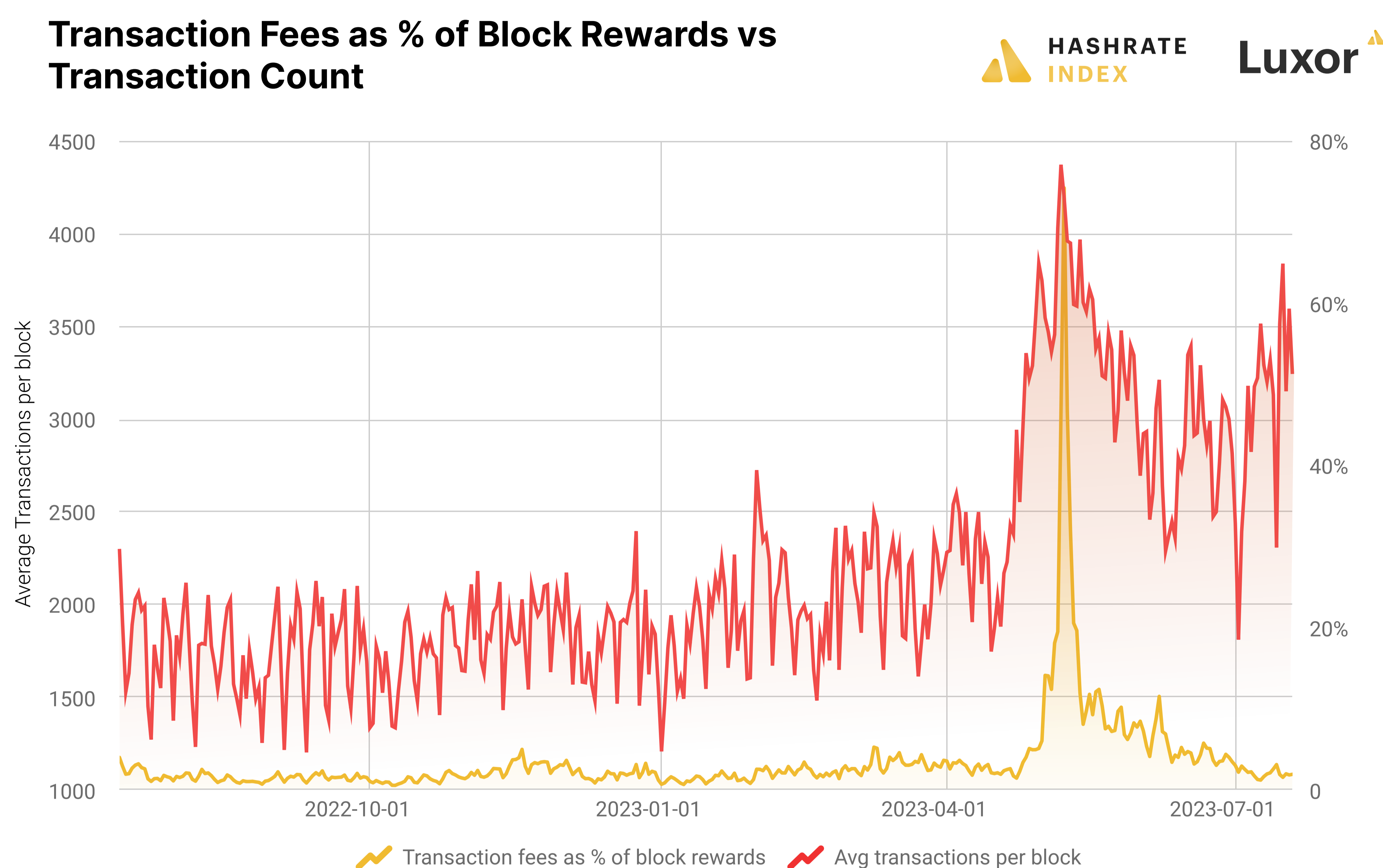
Inscriptions, ordinals send transaction fees to multi-year highs

Casey Rodarmor first introduced the concept of ordinals and Inscriptions in January of this year, though he and others were playing with the tech in December.

Inscriptions caught the imagination of the cryptosphere in February and early adopters rushed to inscribe collections of digital art and miscellany. The novel NFT method attracted many NFT traders, collectors, and creators from the Ethereum ecosystem, a migration that would accelerate the mania and transaction fee boon. **To date, there are more than 19.6 million inscriptions on Bitcoin's blockchain.**

The early adoption of ordinals and inscriptions in February immediately doubled the transaction fee revenues miners became accustomed to in 2022. **In 2022, the average share of block rewards from transaction fees was 1.63%; So far in 2023, the average was 2.3% in Q1, 8.11% in Q2, and 4.9% year-to-date.**

When the mania peaked in May, miners were earning more from fees than they were from the block subsidy. Indeed, it wasn't uncommon to see blocks that had 12.5+ BTC in rewards, which was last halving epoch's block subsidy.

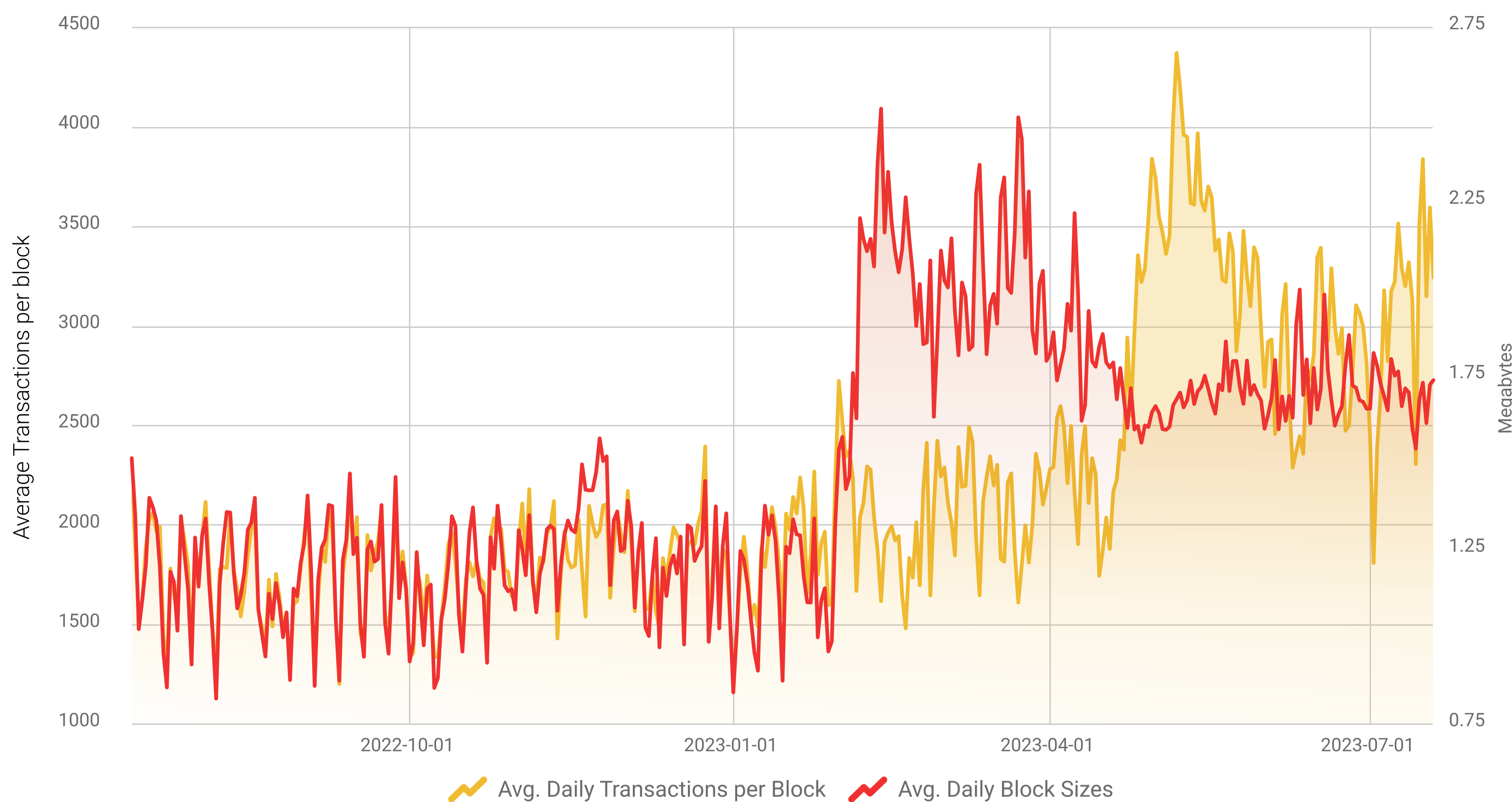


Inscription blockspace dynamics

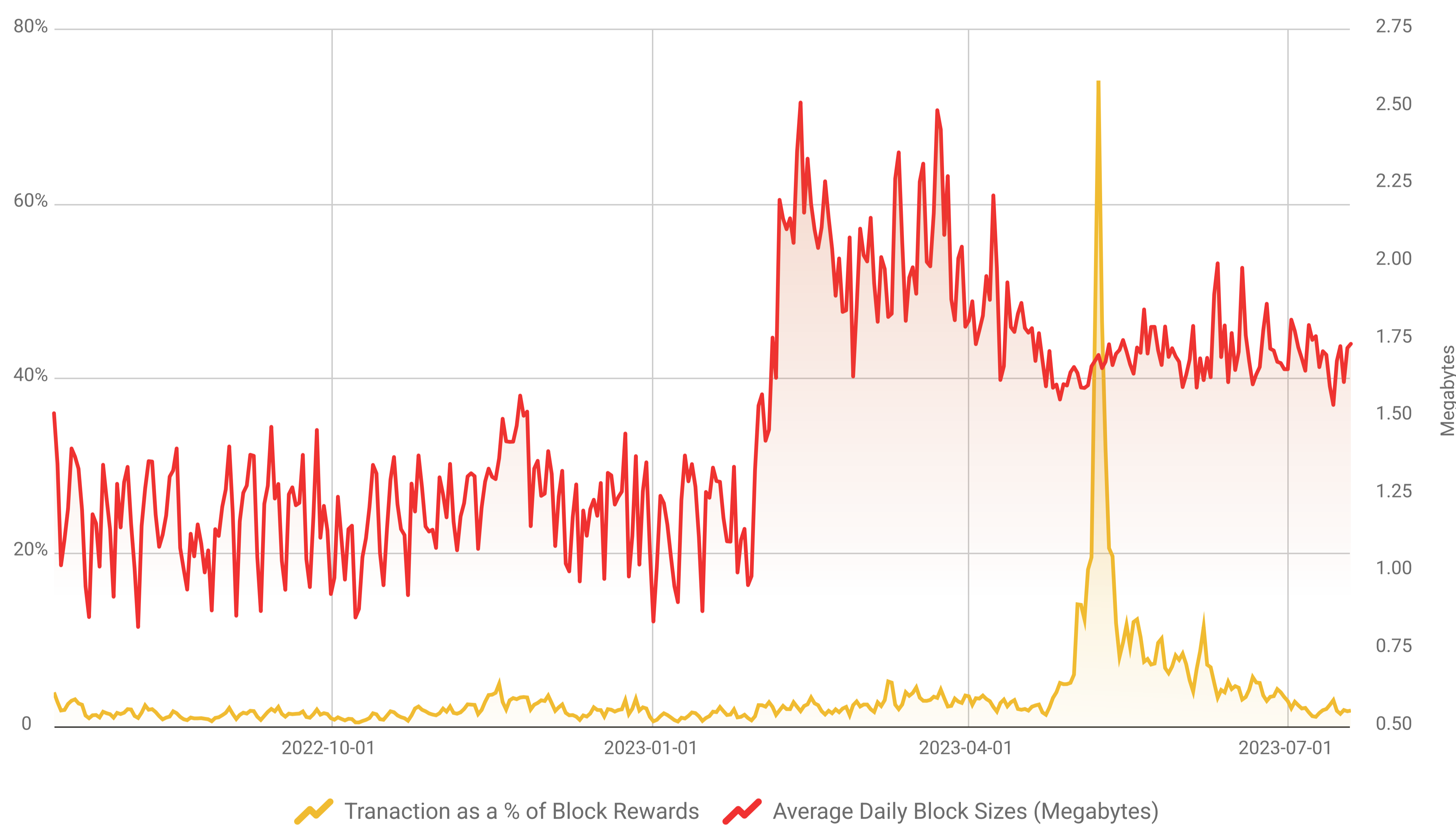
Inscriptions have been controversial for a number of reasons, not least of which because they benefit from SegWit's data discount. The data for the inscription lives in the transaction witness section of a block that was introduced with 2017's Segregated Witness (SegWit) upgrade. Witness data is cheaper to transact per byte than data included elsewhere in the transaction, so inscriptions cost fewer satoshis per byte of data than a normal, economic transaction.

We can observe the SegWit discount in full effect in the chart below: the gap between transaction counts and block sizes from February to May best demonstrates the witness discount's impact on early inscription fee dynamics. Blocks were filling up with arbitrary inscription data like images and text, but the transaction count – increase though it did – did not increase astronomically.

Average Daily Transactions per Block and Average Daily Block Sizes



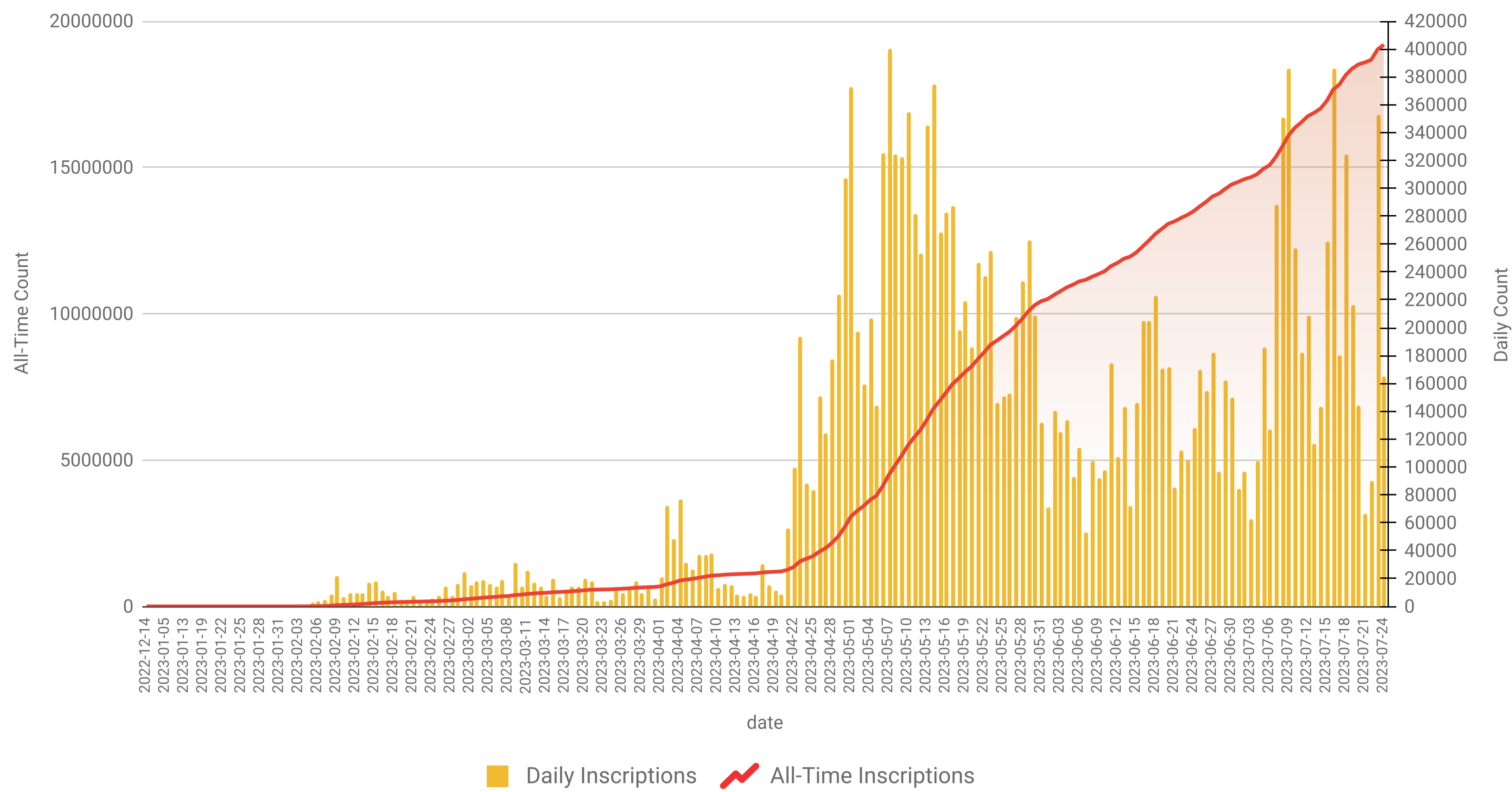
Transaction Fees as a Percentage of Block Rewards vs Block Sizes



The rise in transaction counts and the real rise in fees would come later, in Q2, when “BRC-20 tokens” gripped the inscription market. The first wave of inscriptions were mostly jpegs and other image formats that benefited from the discount, but BRC-20 transactions demand less witness space, more transaction field space, and they incentivize an entirely different level of trading activity.

As the chart below demonstrates, activity ramps up in April and hits a peak in early May.

Daily Inscription Count and All-Time Inscription Count (Source: DataAlways' Dune Dashboard)



First introduced in April of 2023, the BRC-20 standard finally brought Ethereum-like minting incentives to the inscriptions landscape. Before, inscribers would mint an entire collection and then auction off these images in very basic OTC fashion in Discord servers, on Twitter, and other forums; unlike popular NFT collections on other chains like Ethereum and Solana, where users could mint their own NFTs from auctions, this option did not exist or inscription collectors.

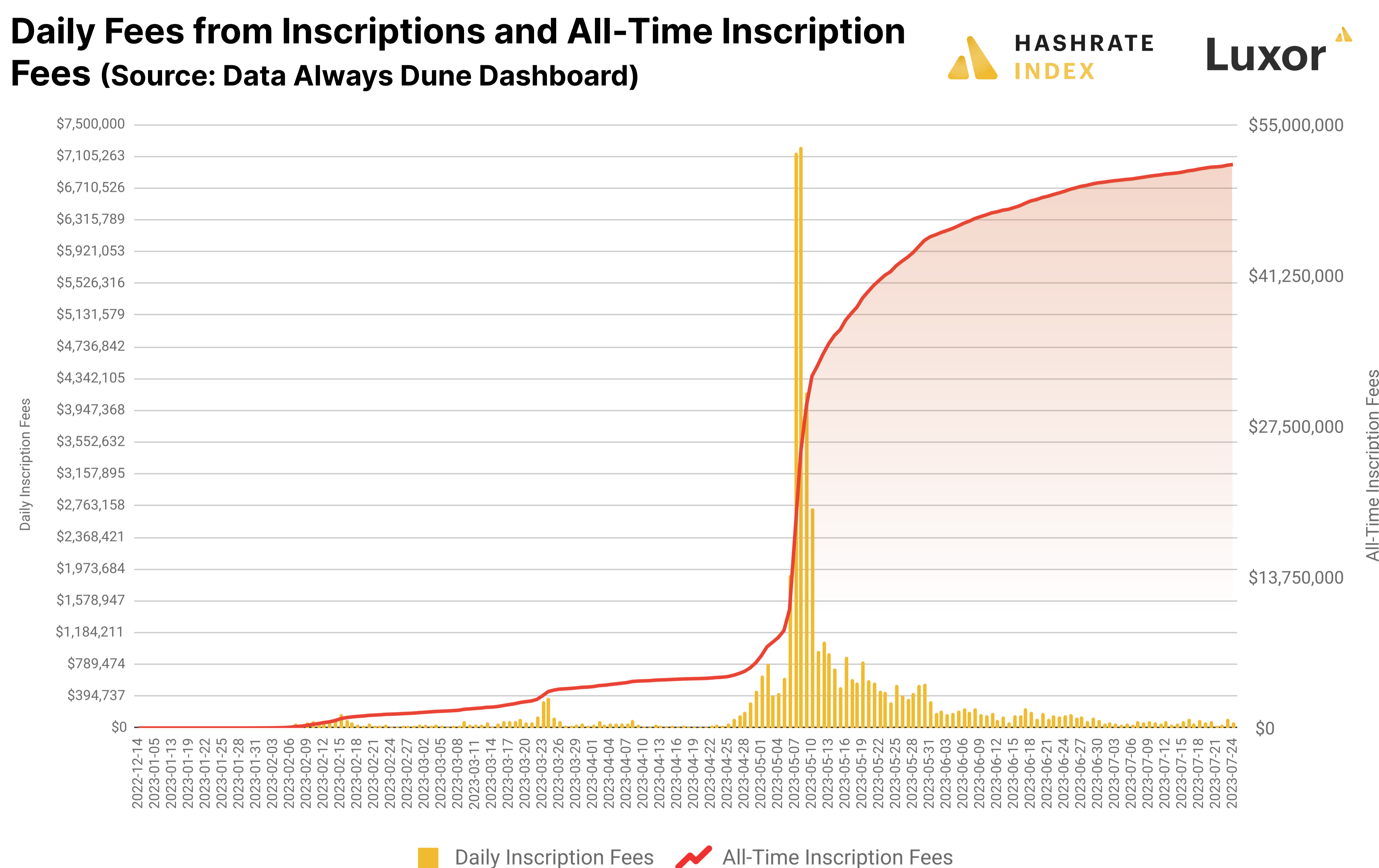
The BRC-20 standard changed this. Now, using Bitcoin's OP_CODE field, collection creators could create a token parameter with a set supply. After they broadcast the template, anyone can mint tokens in the series if they follow the token's parameters. When BRC-20s caught fire in May, the first-come-first-mint mechanism incentivized inscribers to bid up fees to be the first to mint a new series. These minting transactions are also OP_CODE transactions, so they do not benefit as much from the SegWit discount and thus cost more on a per byte basis.

```
{
  "p": "brc-20",
  "op": "deploy",
  "tick": "ordi",
  "max": "21000000",
  "lim": "1000"
}
```

An example of a BRC-20 OP_CODE template

The minting incentives and the fact that BRC-20 transactions don't benefit greatly from the SegWit discount led to the transaction fee spike we see in May in the chart below.

We can also observe in this chart that, following the parabolic spike of activity in May, ordinal / inscription activity started plateauing in July. There is still activity, but nothing like we saw from February to June.



Ethereum’s first NFT frenzy came in the form of CryptoKitties in 2017, but it wasn’t until 2021’s historic bull market that NFTs really started making noticeable cultural impact -- in a virtual performance for the VMAs, Eminem and Snoop Dogg literally performed as Bored Apes for example -- not to mention economic impact on miner bottom lines.

We expect ordinals and inscriptions to have similar staying power and to create cyclical transaction fee boom and bust cycles, particularly during bull market conditions when interest in Bitcoin and crypto is high.

We’re not saying that miners should bet the farm on the hope that inscriptions keep hashprice afloat. But we do think that digital collectibles have captured the cultural conscience and that the inscription trend has promise to bolster miner revenues in the future, especially as developers and entrepreneurs tinker with new applications for blockspace generally.



4

ASIC prices stabilize

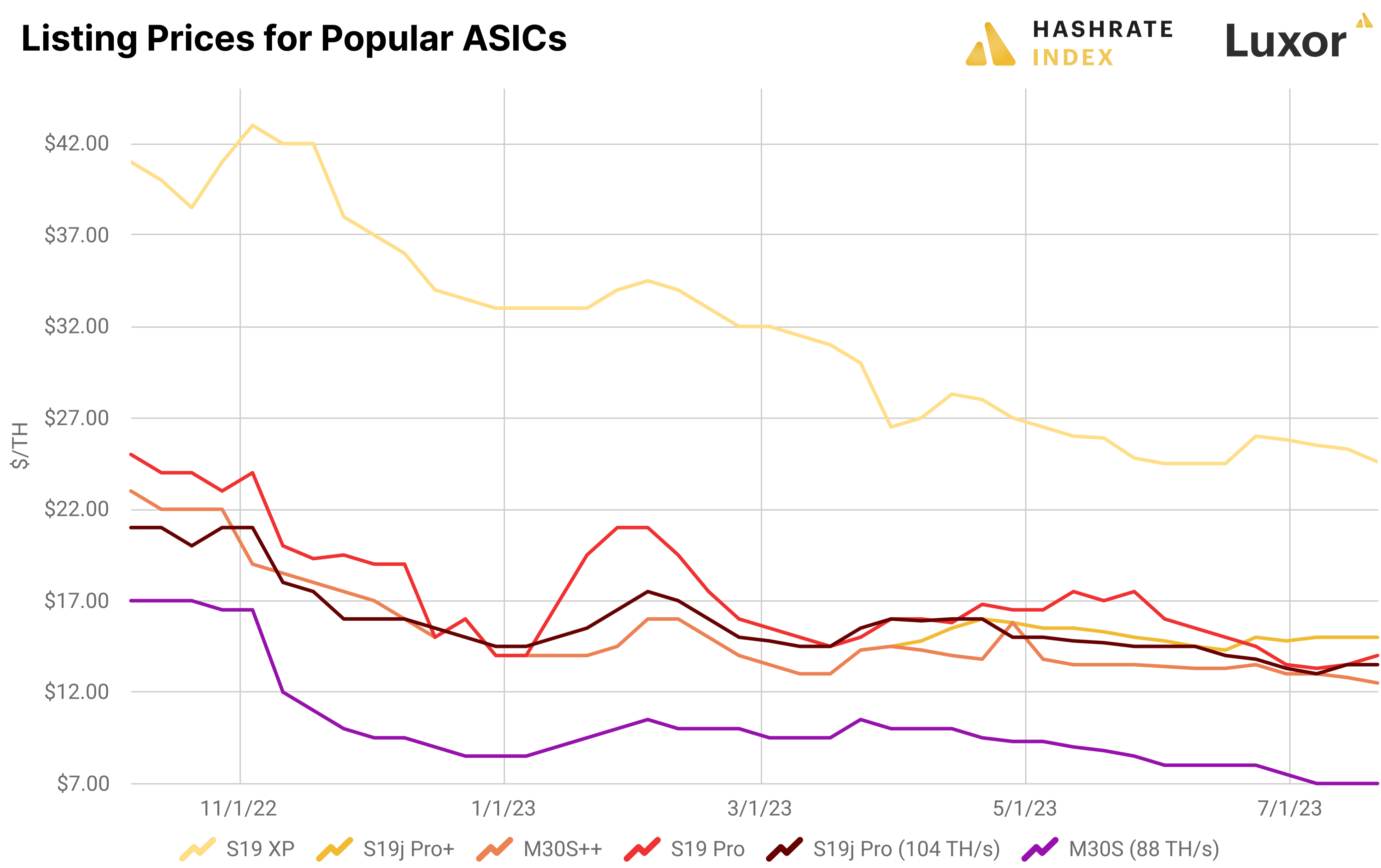
Bitcoin mining ASIC prices have been in freefall since December 2021, the end of the last bull market. But in Q3 of 2023, ASIC prices seemed to find something of a floor – for now at least.

Prices still mostly declined quarter-over-quarter, but the market is showing signs of stabilizing in July, particularly for next-gen rigs. Below we list the quarterly change of asking prices for popular ASICs (data pulled from Luxor’s ASIC Trading Desk):

- S19 XP (-2.64%)
- S19j Pro+ (2.07%)
- M30S++ 112 TH/s (-10.34%)
- S19 Pro 110 THs (-15.63%)
- S19j Pro 104 TH/s (-16.88%)
- M30S 88 TH/s (-25%)

Something that becomes immediately apparent: lower-hashrate new-gen rigs, like the S19 and M30S, are falling out of favor and next-gen equipment, like the S19 XP, are seeing increasing price premiums as miners seek out the most efficient equipment to prepare for the halving.

Visualizing the price changes in Q2, we can see that, despite the decline in Bitcoin miner prices over Q2, prices started bouncing in June and into July, particularly for next-gen equipment as previously mentioned.



Source: Luxor ASIC Trading Desk

Notably, we've seen the S19j Pro+ increase in value over the quarter to the point that it now has a premium per terhash when compared to other S19j series rigs. The S19j Pro+ is just now coming to market, and as with new hardware in the past, prices were lower when miners were making futures orders and the machine's performance was unknown. As miners see the S19j Pro+ in action and trading moves from the futures market to the spot market, prices are rebounding as uncertainty dissipates and the model becomes more accessible. We've seen this pricing dynamic before with the S19XP, which just came to market in the summer of last year.

It's also worth noting that new-gen machines like the S19j Pro, S19 Pro, and M30S++ are trading in a tight band currently. Older models of these series, like the vanilla S19 and M30S, are starting to fall out of favor for most operators, as evidenced by the M30S's price decline illustrated in the chart above (you can see the M30S's value drop off a cliff in November 2022, a time when hashprice fell to all-time lows).

For your miner with average or above average power costs (say, \$0.075/KWh), any machinery with an efficiency worse than 34 J/TH is not worth the investment right now (unless Bitcoin mega moons in the next 12 months, a scenario that we wouldn't bet the farm on and which we analyze further in the ASIC ROI section of this report). With the halving looming and a slew of new hardware coming to market in 2023 and 2024, some of the new-gen machines of yesterday will become the mid-gen machines of tomorrow. However, depending on the \$/TH price, investing in mid and new gen machines could be a profitable flipping strategy if a bullmarket materializes in 2024/2025, as we saw last year when miners purchased S9s for pennies (or got them for free) and sold them at the peak of 2021's bull market for \$50/TH.

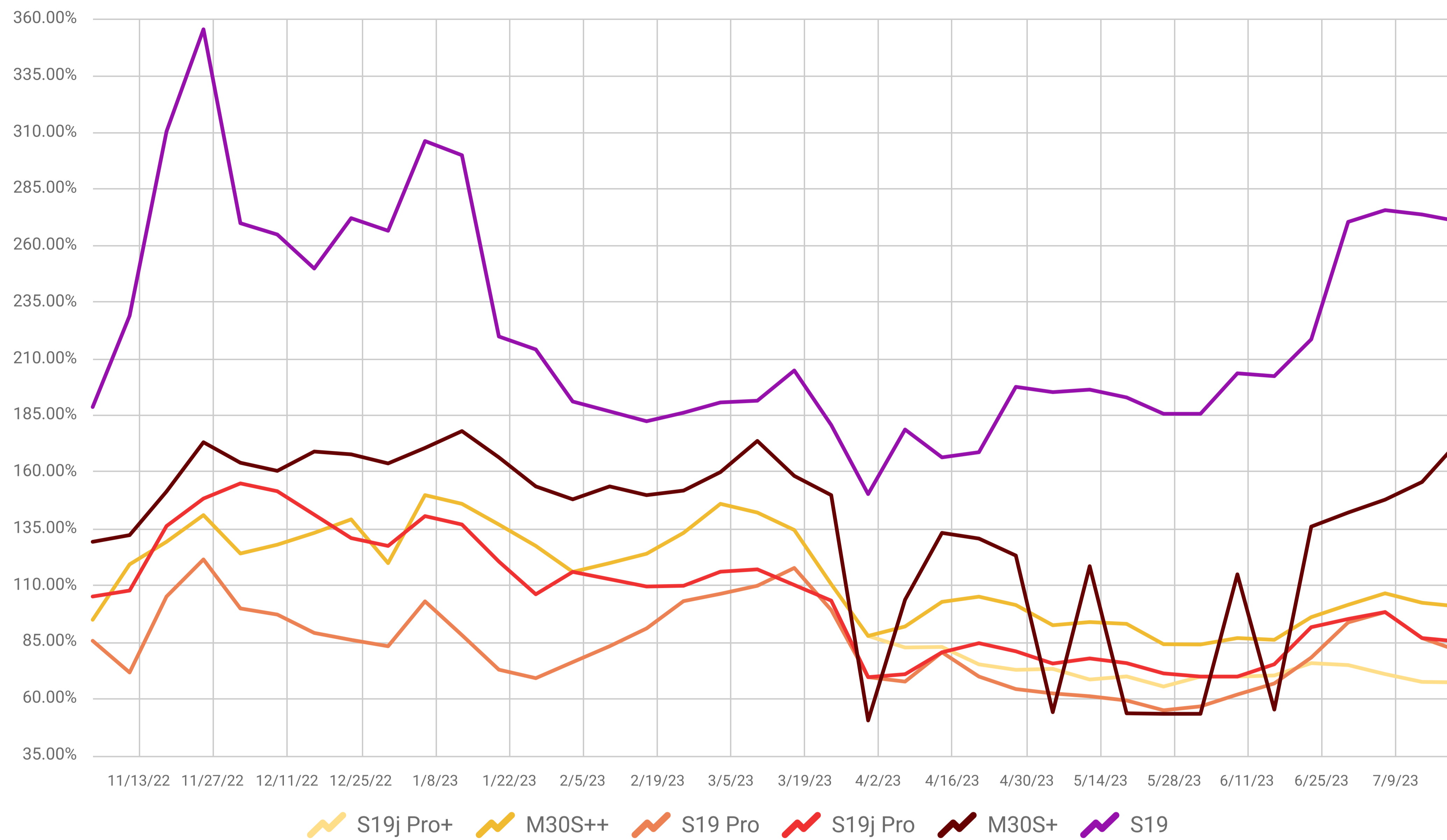
S19 XP, next-gen premiums rise

As miners prepare for the 2024 Bitcoin Halving and expand their fleets, hashprice and bitcoin price scenarios aren't the only factors miners are weighing when evaluating hardware. Bitmain and MicroBT have released several new models in 2023, and like all new hardware, miners are uncertain about their performance.

The Antminer S19 XP – the flagship for Bitmain's next generation hardware – has been tested in the field for a year now, and miners generally consider it a solid rig, despite a few design choices (like covering one side of each hashboard with aluminum plating, as reported by Compass's Mining Memo).

As Bitcoin miners prepare for the halving, they are prioritizing hardware with leading efficiency and hashrate. As such, price premiums for next-generation machines like the Antminer S19 XP, Whatsminer M50S++, and similar rigs are rising compared to their older counterparts.

S19 XP Premium vs. Other Popular Rigs



Source: Luxor ASIC Trading Desk

As evidenced in the chart above, S19 XP premiums hit a local low in Q2, but they have been on the rise since June. As we enter Q3, S19 XP premiums are approaching the highs they hit at the end of last year, a time when bitcoin was trading \$15-16k and every armchair analyst was calling for lower prices. With Bitcoin's price undergoing a swift recovery in Q2 – and with hashprice bolstered by this recovery and higher-than-usual transaction fees from ordinals / inscriptions – the relatively low premiums we witnessed last quarter were a reaction to improved market dynamics. When mining margins are healthier, miners don't have the same dire need for top-efficiency hardware, so XP premiums drop accordingly. Now that hashprice is back in uncertain waters, particularly with the halving 9 months away, these premiums are on the rise again as miners increasingly price hardware according to post-halving mining economics.

We've also noted that prices for the M50S series are carrying a premium compared to the Antminer S19 XP. We postulate two reasons for this premium: 1) Bitmain produces X amount more rigs than MicroBT and so has access to better pricing from chip manufacturers, and 2) Whatsminer are earning a reputation as a sturdy alternative to Antminers.

One last thing to note: manufacturer coupons have dried up. Manufacturers offered these as incentives to sell inventory when bitcoin was in the pits and miners weren't purchasing rigs, but these discounts are essentially gone for now.

New vs. used price spreads

As miners plan for the halving, they're not just prioritizing next-gen hardware – they're also preferring new rigs to old. The price premiums for new equipment have steadily increased over the year.

New rigs and hydro and immersion models

Speaking of new rigs, here are some new ASIC models that were released last quarter:

- S19j XP (151 TH/s | 21.5 J/TH)
- S19k Pro (136 TH/s | 24 J/TH)
- M50s++ (150 TH/s | 22 J/TH)
- M56s++ (Immersion: 230 TH/s | 22 J/TH)
- M53s++ (Hydro: 320 TH/s | 22 J/TH)

We're starting to notice the emergence of more hydro and immersion-outfitted mines, particularly as manufacturers expand their offerings for these types of ASICs and as the halving approaches. Under normal conditions, these machines can offer miners double the hashrate that air-cooled models deliver for the same power input, and when they are overclocked, they can provide even more.

But this output comes at a cost: higher CAPEX, more hardware, and more maintenance.

1. **Hydro Cooling:** hydro cooling also known as liquid cooling, utilizes cold plate water cooling technology which uses deionized water as the heat transfer medium. Unlike immersion cooling, hydro cooling typically uses a closed-loop system in which water is circulated through heat exchangers without coming into contact with the electrical components. This method allows for efficient heat transfer due to the higher heat capacity of water compared to air and oil. Hydro cooling offers advantages such as improved cooling efficiency, scalability, flexibility, and lower operating costs impact compared to air cooling solutions.
2. **Immersion Cooling:** Immersion cooling involves submerging electronic components, such as servers or ASIC chips, into a non-conductive liquid or coolant. This cooling method enables direct contact between the components and the coolant, providing superior heat dissipation. Immersion cooling offers numerous benefits, including improved cooling efficiency, reduced thermal stress, increased performance, extended equipment lifespan, and a smaller physical footprint. By eliminating the need for air cooling, immersion cooling enables higher-density deployments and reduces noise pollution in computing environments.

The infrastructure supporting immersion and hydro cooling systems share many similarities. The main components of an immersion cooling system include:

- Tank
- Coolant
- Pumps
- Filtration system
- Heat exchangers
- Control system
- Power distribution units (PDUs)

The main components of a hydro cooling system include:

- Racks
- Coolant
- Pump filtration system
- Heat exchangers
- Control system
- Power distribution units (PDUs)

The biggest difference is the coolant being used in the systems (water vs dielectric oil or similar non-conductive fluid).

Hydro cooling systems employ special deionized water as the coolant. Maintaining water quality and minimizing environmental impacts are crucial aspects of hydro mining setups. Miners employ a number of technologies and practices to keep their hydro Bitcoin miners tuned up, such as filtration systems for sediment and debris removal, regular water quality testing, pH adjustment, contaminant removal through chemical treatment, and adherence to environmental factors. Implementing water recycling and reuse systems helps reduce water consumption, and compliance with local regulations ensures proper discharge management. During the tour, MicroBT recommended using first-level deionized water meeting national standard GM/T 6682-2008.

In an immersion cooling system, the fluid must be non-conductive because it comes into direct contact with the ASIC components. The selection of coolant depends on various factors like dielectric properties, thermal conductivity, and compatibility with electronic components. Miners commonly use fluorocarbon-based fluids, such as 3M, Novec, or Galden in immersion cooling systems given their non-conductive nature and high boiling points. These coolants allow for efficient heat transfer while ensuring the safety of the submerged components.

We anticipate that immersion and hydro-cooled mines will continue to steadily produce more of Bitcoin's total hashrate in the coming years. We're already seeing it become the standard in Middle Eastern markets like the UAE – countries which are seeing and will continue to see massive investment in the sector.

Rigs to come in 2024 and 3nm chips

We've heard rumblings that Bitmain's next line of Bitcoin miners, the S21 series, could be released next year.

Originally slated for 2025, the Antminer S21 could be available for preorder next year. The speculated efficiency of these machines is 14-15 J/TH, but it's too early to tell what the exact specifications and hashrate will be. This is all hearsay at the moment, but it's clear that Bitmain is working on a new Antminer series that will be more efficient and powerful than current models.

Though we're just speculating, we'd figure these rigs will use 3nm chips, something that MicroBT is reportedly already doing with Samsung's 3nm ASICs for the Whatsminer M56s++ immersion model.



5

Electricity markets take a chill pill

Electricity markets appear to be normalizing in 2023 after last year's unprecedented electricity price inflation, and many states in the US saw power prices fall from 2022's highs. Bitcoin miners all over the globe are now finally starting to relax as prices normalize, and at least publicly and in the press, the industry is now dedicating significantly less attention to this topic.

Although the situation looks better than last year, miners should be careful with the assumption that we've seen the end of the energy crisis. Severe imbalances are still looming in the global energy market, which could very well again lead to electricity price spikes, particularly if coupled with extreme weather.

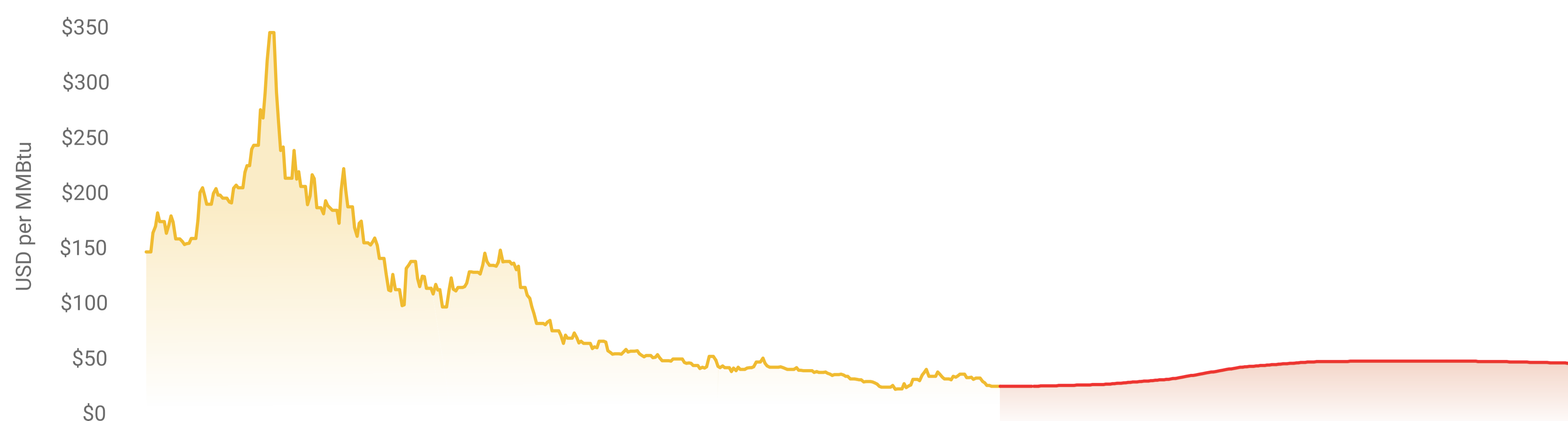
This chapter will discuss trends in energy markets that could positively or negatively impact miners' access to cheap electricity. Based on historical data and future projections, we also analyze which electricity price miners need to hash through and after the halving.

Natural gas prices are normalizing

In most modern electricity markets, the price is set by the marginal production cost of the last-resort source of easily dispatchable power, typically natural gas plants. Given the importance of natural gas prices for electricity markets, this subchapter analyzes the current state of the global natural gas market. It gives background on the latest developments in international power markets so we can better understand where we are headed.

As you can see in the charts below, natural gas prices surged to historic highs in the second half of 2022, both in Europe and in the United States. As always, electricity prices followed, leading to severe problems for the unhedged portion of the global bitcoin mining industry. At the end of 2022, two of North America's biggest Bitcoin mining hosting providers, Compute North and Core Scientific, declared bankruptcy partly due to surging electricity costs, and by the New Year, we were just waiting around for more miners to follow.

Europe Natural Gas Price (Dutch TTF)



USA Natural Gas Price (Henry Hub)



Source: Tradingview

Luckily, in an almost miracle-like fashion, Mother Nature gifted Europe with one of the mildest winters in recorded history. This led to much lower demand for natural gas, which allowed European countries to fill up their inventories. As a result, Europe's benchmark natural gas price (Dutch TTF) plummeted and is currently sitting at its lowest inflation-adjusted level since September 2020 at \$25.96 per MMBtu, corresponding to a 93% decline from its August 2022 peak at \$346 per MMBtu.

The American natural gas benchmark (Henry Hub) also plunged, although to a smaller degree than the European one. It currently sits at \$2.56 per MMBtu, 73% lower than its \$9.34 per MMBtu peak from August 2022.

However, if we are to trust the EIA and the market consensus, natural gas prices will likely slightly increase over the following months. The EIA expects the Henry Hub price to average \$2.80 per MMBtu in the second half of this year, 10% higher than the current \$2.80 per MMBtu. This projection aligns with the market consensus, which according to the futures curves you can see on the chart above, expects natural gas prices to increase slightly towards next winter before falling in the spring.

Natural gas prices are highly unpredictable

So, the experts assume that natural gas prices will stay at relatively comfortable levels in the coming months. We have no reason to go against the consensus here. However, we still want to emphasize that any energy price prediction is tinged with uncertainty in these times of volatile market conditions. With ongoing geopolitical events and structural energy market issues in Europe, forecasting natural gas and electricity prices is a more complicated and unpredictable exercise than it has been historically.

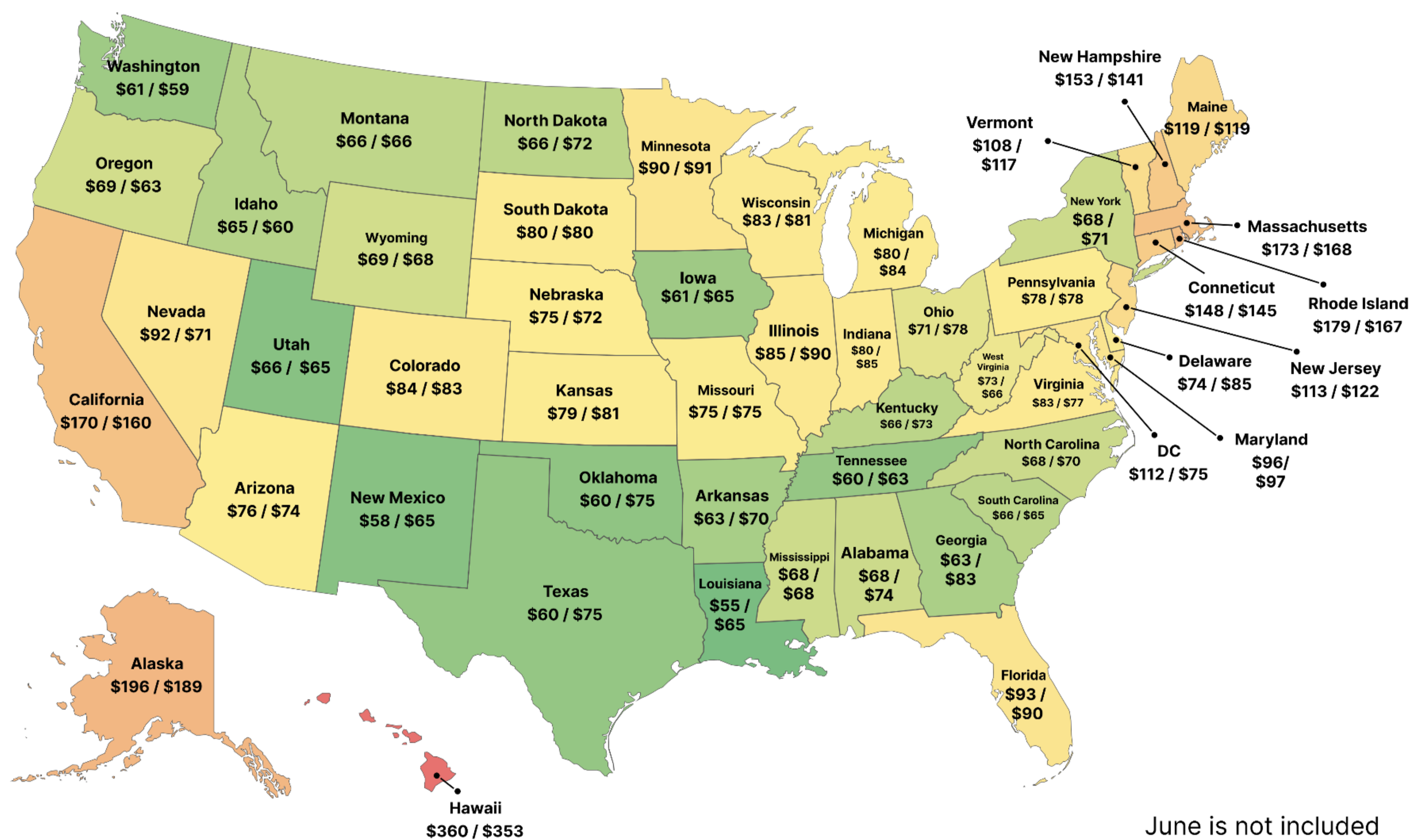
Therefore, miners should brace themselves for the worst possible scenario and ideally hedge their electricity input costs for the coming months and year.

US power prices come down from record highs

Natural gas and electricity prices are intertwined to a point, so the trajectory of natural gas serves as a general lodestar for global electricity prices. In this section, we will look deeper into future industrial electricity price projections by US states.

As you can see on the chart below, electricity prices in most US states have significantly retracted over the past year.

Average Industrial Electricity Prices in the US in Q2 2023 vs Q2 2022



Falling natural gas prices have helped in many states, and 2023's summer has been more forgiving than last year's record heat. As we touch on in a later section, hosting rates have either decreased or stabilized in various states in accordance with power rates.

Projections for future industrial electricity prices by US state

Party lines continue to divide US citizens on every topic from affirmative action to the new Barbie movie, so energy policy certainly hasn't been spared from the culture war's crossfire. Generally speaking (and with Texas being a glaring exception), Red states have prioritized fossil fuel and nuclear baseloads, as well as hydroelectric power (with a sprinkling of renewables where they make sense). Meanwhile, Blue states, the prime examples being California and New York, have prioritized renewable energy like solar and wind at the expense of nuclear and natural gas.

An analysis of summer curtailments in Texas

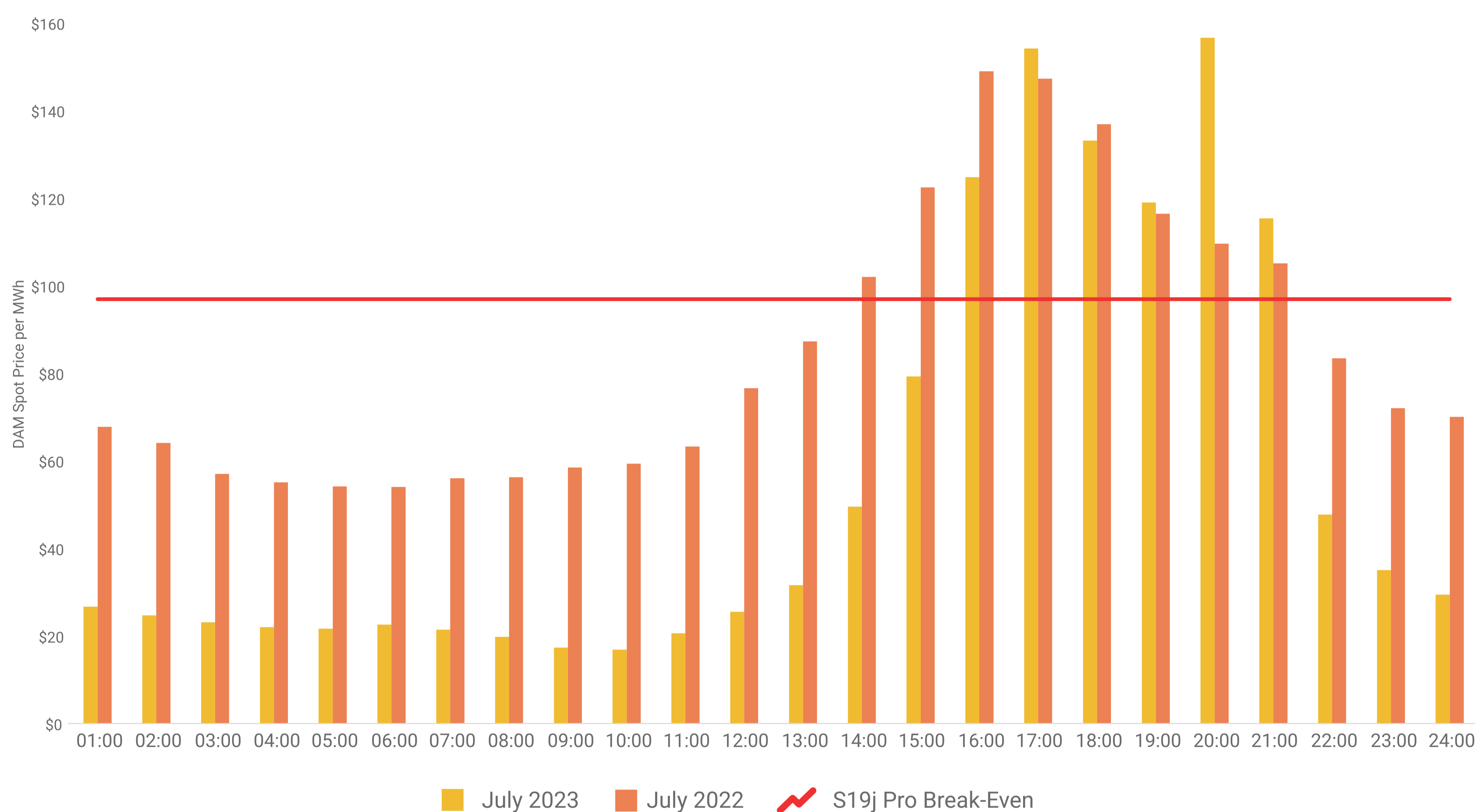
The summer is proving the most challenging season for bitcoin miners in North America for two reasons. Not only do the cooling requirements increase during the summer heat, but spot electricity prices tend to rise as well, because everyone is cranking their air conditioners *and* summer generally tends to be a time of high tourism and travel activity. These rising electricity prices often force miners to periodically curtail their operations. In this chapter, we will analyze how the summer heat is affecting mining operations in Texas.

It's worth noting, though, that the summer has been milder than not in most states, though Texas and California's grids have struggled with renewables at times underperforming during heat and storms.

Luckily, so far this summer, Texas has been spared from the most hellish, record-breaking temperatures, so minus a few periods of stress, miners are curtailing less than expected.

In Texas, as well as other electricity markets, there are several curtailment drivers. A common factor is that miners usually curtail during periods of spiking spot electricity prices. As you can see on the chart below, spot electricity prices in the day-ahead market in West Texas were consistently lower in July this year compared to the same month last year.

West Texas: Average Spot Price by Hour in July 2023 vs July 2022

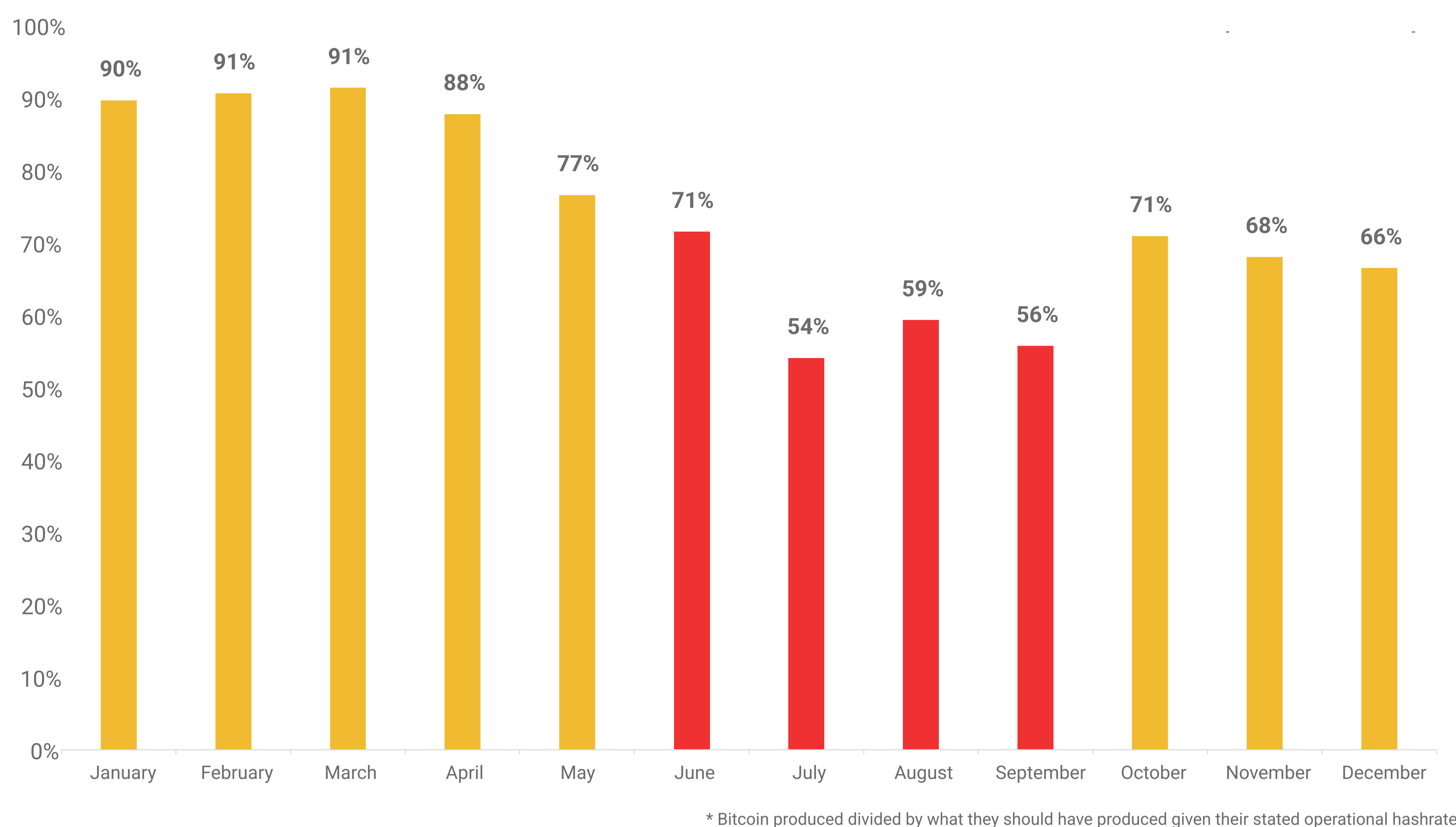


Source: ERCOT

We see that the price bottoms, which occur between midnight and noon, have been considerably lower on average this summer than last summer. However, the peak prices, which usually occur around 5pm, have been slightly higher this summer compared to the summer of 2022.

A large part of Texas' bitcoin mining load curtails once spot electricity prices rise above their mining revenue per MWh, illustrated by the red line in the chart. As we can see, this tends to occur during the six hours between 3pm and 9pm. Six hours of curtailment means most Texas bitcoin miners can expect to achieve an up-time of around 75% during July.

Riot: Monthly Implied Up-Time in 2022



Source: Riot's Production Updates, Hashrate Index

Riot's significantly reduced up-time during the summer months of 2022 gives us a real-world case study of ERCOT curtailments. As you can see on the chart above, Riot consistently achieved an implied up-time of around 90% between January and April. As temperatures and electricity prices increased, the Texan mining behemoth saw its implied up-time fall considerably, only running at between 54% and 71% capacity from June to September. Similar to many other Texas miners, Riot is able to significantly reduce its effective electricity price by curtailing during peak hours.

Different types of curtailments with ERCOT

Miners and commentators throw around terms like "demand response" and "curtailment" a lot, but as evidenced by the fact that Riot is compensated for this service while some other large operators in Texas are not, not all curtailment is the same.

There are four basic types of curtailment services ERCOT provides. (A special thanks to ERCOT's Evan Neel for informing this section.)

1. Economic curtailment: This method is dependent on the spot price in the day-ahead or real-time market. For miners hedged with a PPA, their contracts almost always have the optionality to forego their contracted power and have the power provider sell it into the spot market instead. The miner then settles financially with its power provider and collects the difference. This means that it is in some miners' best financial interest to curtail when spot prices are high, even though they can mine profitably off their fixed rate. Therefore, in the case of many hedged miners, they don't necessarily curtail because mining is unprofitable – they curtail because the arbitrage opportunity outweighs the mining opportunity. Unhedged miners operate the same way, except without the arbitrage. They simply curtail if the spot electricity price rises above their mining revenue per MWh. By avoiding the highest-priced hours, they can significantly reduce their effective electricity cost.

2. 4 Coincident Peak (4CP) Program: This demand response program is intended to allocate transmission costs, which are based on the total average consumption during the peak load intervals of the four summer months (January - September). By avoiding consumption during those intervals, loads can save a significant amount of money in the long run. Typically, most miners will operate conservatively during the summer so as to not be caught consuming electricity during one of those intervals. This is typically observed by total curtailment of the sites from early afternoon through the evening. The majority of miner curtailment during the summer can likely be attributed to this signal.
3. Ancillary Services: Ancillary services are reliability products that ERCOT competitively procures in the day-ahead market. Since they are reliability products, they serve as tools for operators to dispatch in order to balance the grid. Qualifying Large Flexible Loads (LFLs) are able to participate in these markets if they are a registered non-controllable load resource with under frequency relays installed or a registered controllable load resource. For LFLs that are awarded an obligation, they are paid the market clearing price for the product and are required to maintain a specific MW consumption threshold during the time that the contract stipulates they must be flexible with their load (if the grid needs the power, they tap it; if they don't the miner keep hashing).
4. ERCOT Issued Alert: Some LFLs may curtail when ERCOT issues an alert during a time of emergency energy shortages (like winter storm Elliott, for example). This type of curtailment is rare and usually occurs in the winter, but it is unlikely in the summer months.

This summer has been more benevolent than expected

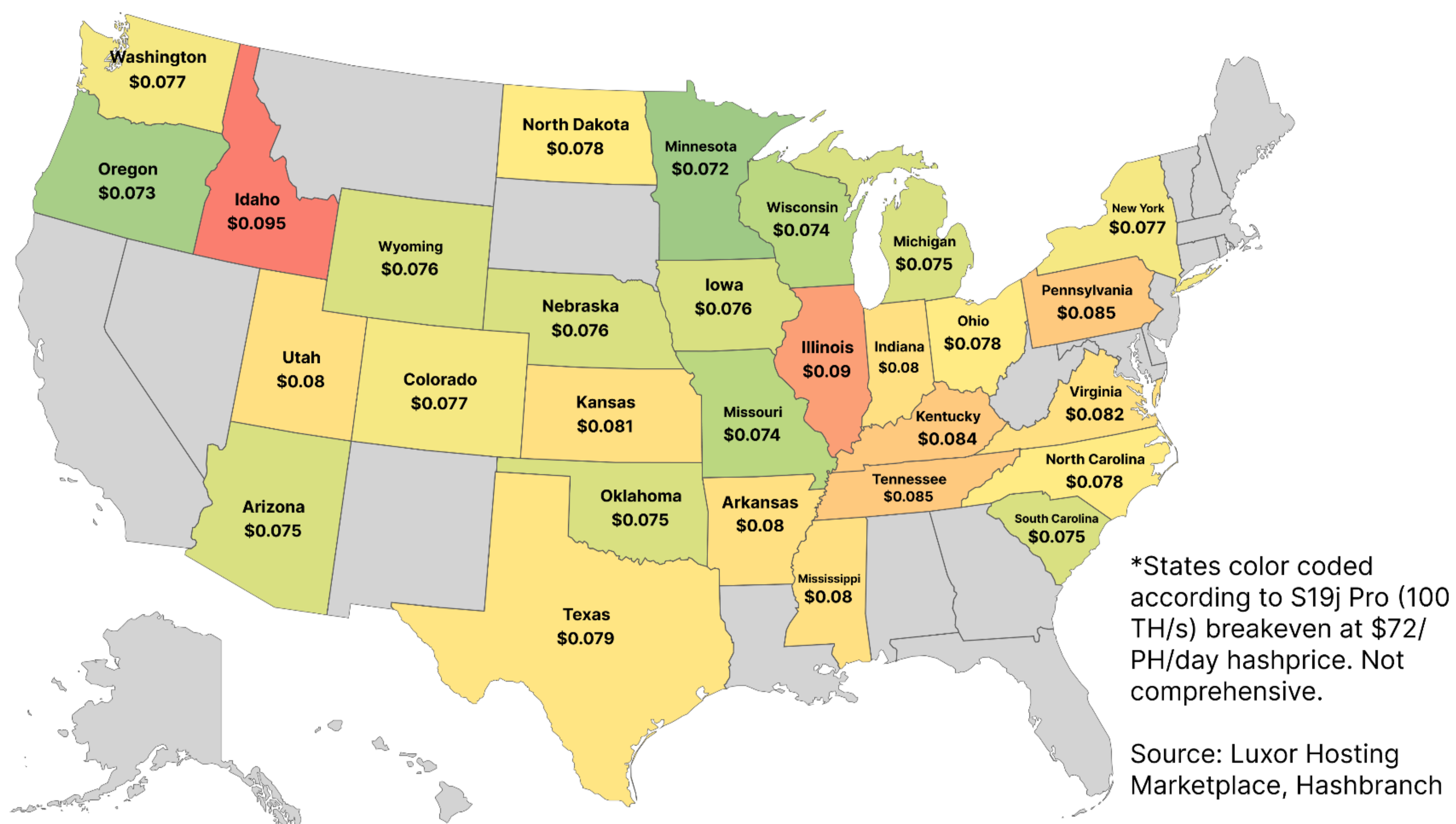
August and September are also historically hot months in the US, but significantly less so than July. Given that we are already past the hottest month, it looks like bitcoin miners in Texas and the rest of the US will get through this summer without any major issues.

US hosting rates stabilize with power markets

In 2021, even retail miners in the United States were able to negotiate all-in hosting rates in the \$0.07 per kWh range. These favorable market conditions would not last long, as electricity price hikes forced co-locators and hosts to jack up their rates in Q3 and Q4 2022.

In January 2023, according to our hosting index, the average retail hosting rate in the United States hit an all-time high of \$0.081 per kWh, dangerously close to the break-even electricity price of the Antminer S19j Pro at the time (\$0.082 per kWh).

Luckily for miners, electricity rates cooled in Q1 2023, so hosting rates fell accordingly. Since then, both electricity prices and hosting rates have stabilized. Currently, the average retail hosting rate in the United States is \$0.077 per kWh, 6% lower than the start of the year.



Source: Luxor Hosting Marketplace, Hashbranch

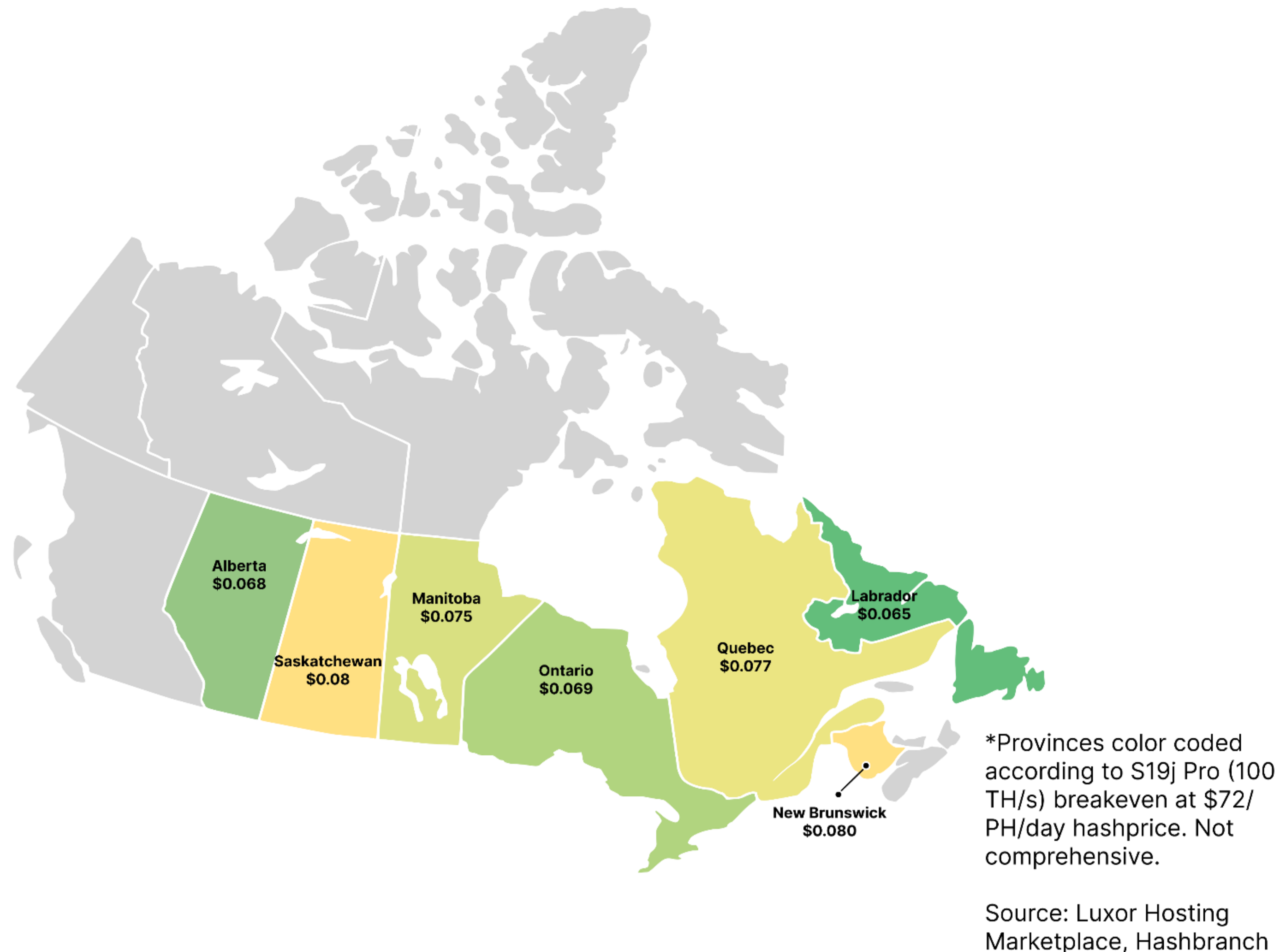
As you can see on the map above, hosting providers in Minnesota, Oregon, Wisconsin, Michigan, Oklahoma, and South Carolina currently offer rates at or below \$0.075/kWh. Meanwhile, Idaho and Illinois are the most expensive states at \$0.095 and \$0.09 per kWh.

Keep in mind that we have significantly fewer observations for these states than for bigger mining states like Texas or Ohio. As we can observe from the table on the next page, the states with more data points tend to give us larger spreads between small MOQ rates and large MOQ rates as the market for rack space is more robust.

Generally speaking, we are seeing hosting rates rise or fall according to the power price changes in each state, and the states with the most data points reflect this correlation most clearly. Additionally, hosting providers are learning from 2022's power market volatility; contracts are becoming more flexible, shorter-termed, and subject to month-by-month adjustments, and long-term contracts (2-5 years) are becoming very rare. Hosts are increasingly signing "power pass through" contracts which allow them to pass on changes to power costs to clients; this has become particularly common in the oil-field mining sector, where oil field operators, privier than ever to hashprice economics, are passing on rise in natural gas prices by re-balancing contracts on a monthly or quarterly basis.

Hosting Rates in Canada

Average Hosting Cost per Province in Canada*



Historically, hosting rates in Canada have been slightly lower than the United States. The country is flush with hydro power, but new miners have had a hard time breaking into the market due to lack of regulatory clarity (more on this in the section on Canada at the end of the report). Operators in Labrador are offering the lowest hosting rates at an average of \$0.065 per kWh. Meanwhile, New Brunswick and Saskatchewan are the most expensive provinces at an average of \$0.080 per kWh.

Final Thoughts on Hosting

As the price of natural gas has risen since 2020, oil well sites and stranded-gas operators have generally ratcheted up their prices as well. Behind the meter and stranded gas operators are becoming privy to hashprice economics, and as they've come to understand the Bitcoin mining market, they are opting for more balanced profit shares; whereas miners used to secure contracts for 80/20 or 70/30 profit share, where gas operators would earn 20-30% of mined profit (or revenue in some cases), miners are now securing contracts for 60/40 or 50/50. Stranded gas hosting sites are increasing hosting rates alongside on-grid (or behind meter on site) nat gas. Hosting at hydro facilities offers the best mix of uptime and cost.

The United States and Canada offer the most liquid and transparent hosting markets and, therefore, come at a premium compared to other countries. European miners also seem willing to pay a premium to host their machines relatively nearby in the Nordics, driving up retail hosting rates in this region to around \$0.09 per kWh.

Miners unwilling to pay such premiums have historically sought hosting solutions outside of North America, like Paraguay or Russia, where hosting rates have been considerably lower. Paraguay has not seen any significant changes in hosting rates over the past few months, with the average retail rate sitting at \$0.0625 per kWh.

According to rates observed by Luxor's business team, hosting rates in Russia have slightly increased and sit at around \$0.055 per kWh for retail clients. Many European and North American miners have withdrawn from Russia over the past year or so amid economic sanctions and the war in Ukraine. This exodus left a vacuum of rack space, which was promptly filled by Chinese, Kazakh, Iranian, Russian, and certain risk-tolerant western miners. You can read more about mining in these countries in chapter 5.

So, what could happen to hosting rates over the coming months? Let's focus on the biggest market - the United States. Just like in any other market, hosting rates are determined by supply and demand. In 2022, we saw supply shrink as electricity prices skyrocketed. Meanwhile, demand held up strongly due to the backlog of mining investments undertaken during the bull market of 2021, as well as many western miners withdrawing from Russia.

We anticipate that hosting rates will likely stay flat over the next quarter. That said, power contracts, particularly for industrial consumers, are becoming more sophisticated. For on-grid operators, demand response, curtailment, and similar power management strategies will be key for maintaining low operating costs up-to and after the halving. Some contracts, like agreements for wind or solar powered mining farms, for example, may offer low-uptime (10-16 hours) for a lower electricity rate (\$0.03-4/kWh); on the flip side of the same token, hosting at a nuclear or hydro site, where uptime can be 95%+, may be more expensive (\$0.06-8/kWh).

Since China's mining ban, there's been increased interest in Bitcoin mining in North America among retail investors. Typically, these miners deploy smaller fleets (maybe 1-10 miners), so they can't command the same negotiating power with hosts or power companies for better rates. As such, retail miners with all-in hosting/power costs at or higher than \$0.075/kWh should be evaluating their post-halving strategies.

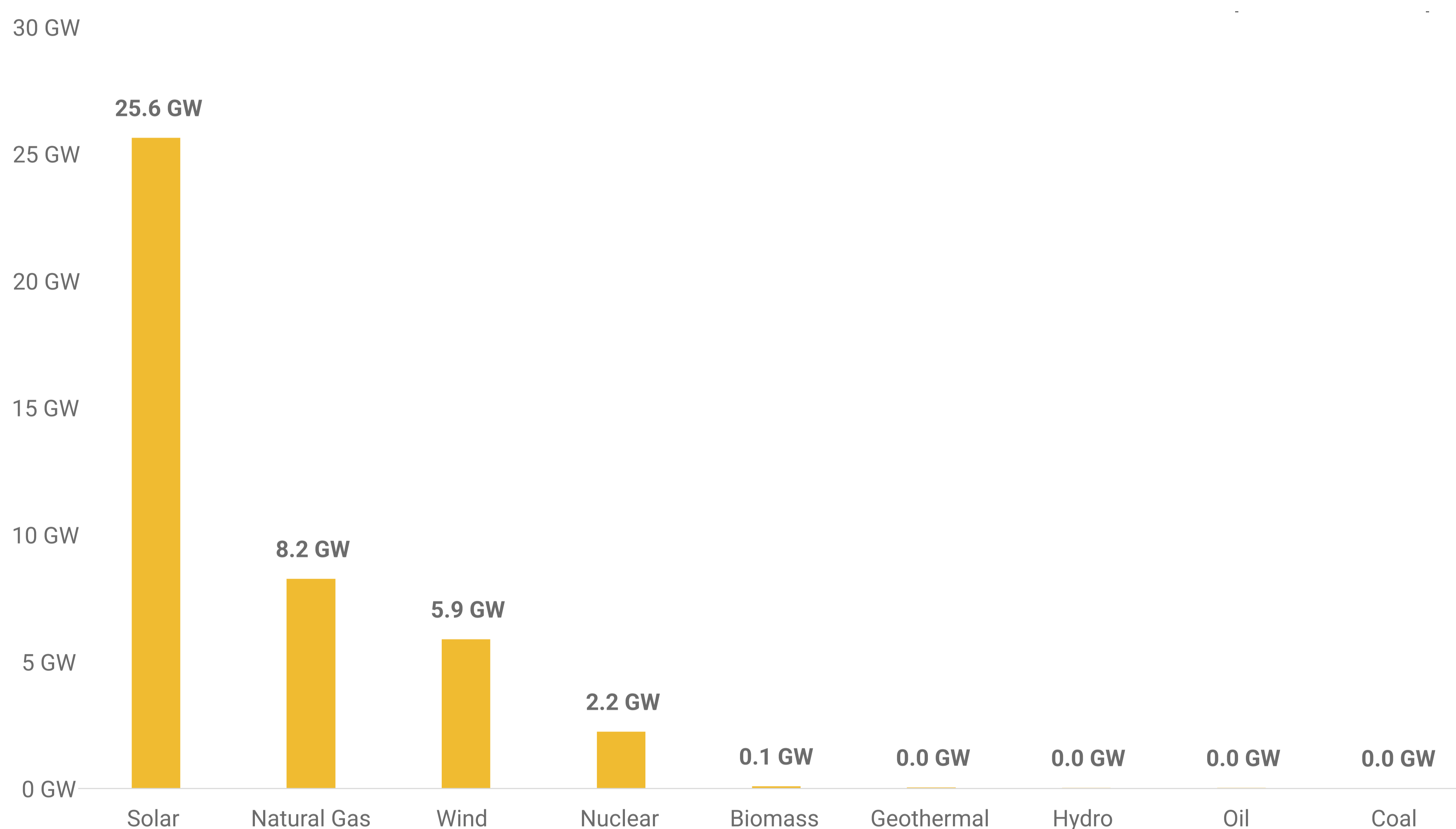
US to add 25.6 GW in 2023

This section will touch on general trends in electricity supply chains and introduce some big electricity generation projects relevant to bitcoin miners. Although we will focus on the United States, we will also mention some projects in emerging mining countries like the United Arab Emirates and Finland.

Let's start looking at the trends in the electricity supply chain in the US. The big trend in the US electricity supply over the past few years has been the replacement of coal with natural gas for baseload generation coupled with a rapid expansion of wind and solar capacity. This trend has culminated in 2023, as it is the biggest year ever both in terms of coal plant retirements and solar plant commissioning.

Solar accounts for more than half of the US' planned electricity supply growth in 2023.

Planned Additions to US Electricity Generation Capacity in 2023 by Source



Source: [EIA \(January 2023\)](#)

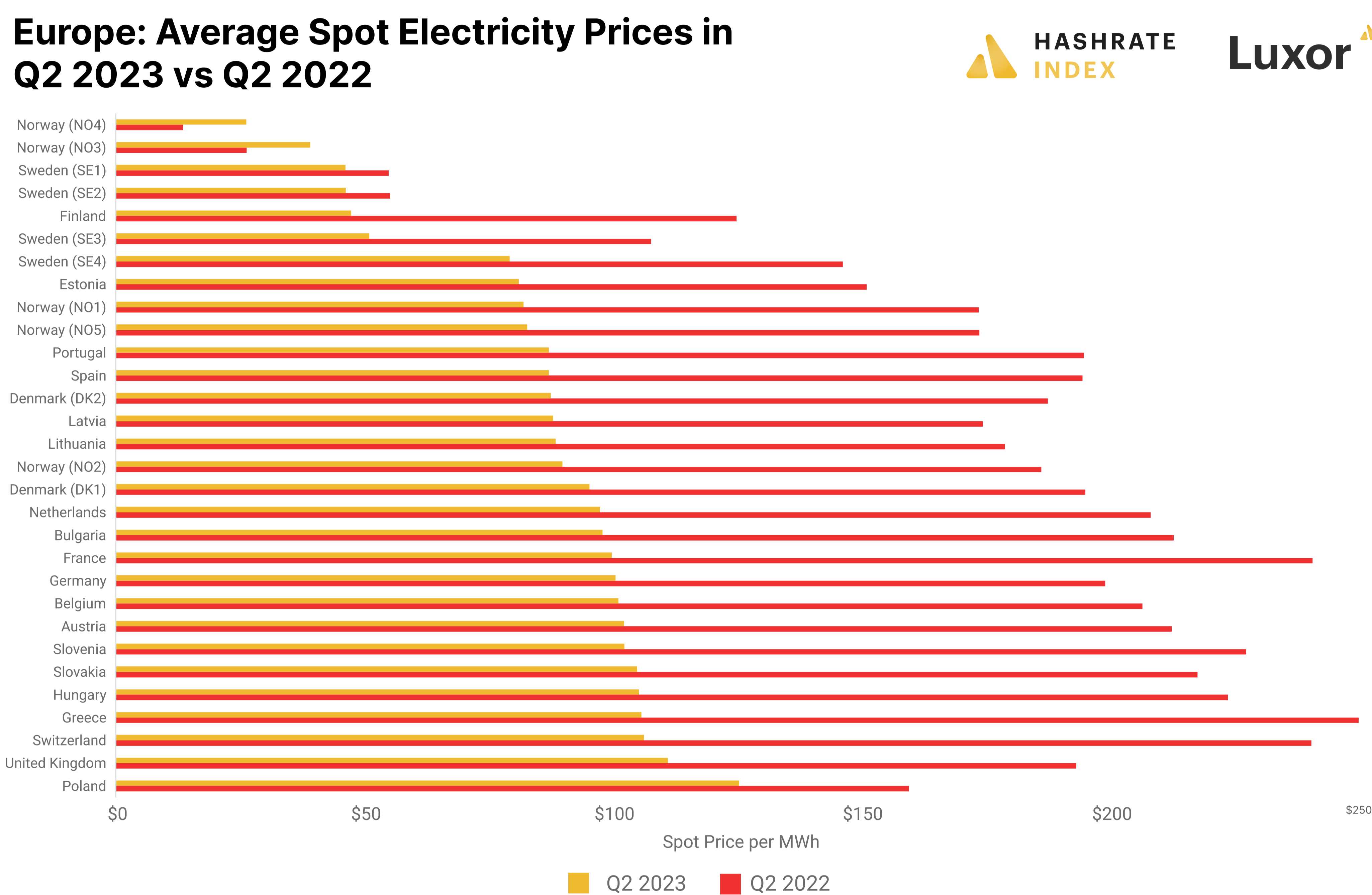
As you can see on the chart above, the EIA estimates that in 2023, developers will add 25.6 GW of solar, 8.2 GW of natural gas, 5.9 GW of wind, and 2.2 GW of nuclear. Meanwhile, we will see no meaningful new power plant additions for biomass, geothermal, hydro, oil, or coal.

Could Europe become viable for bitcoin mining?

In the past years, miners have been flocking to the Nordic outposts of [Norway](#), [Sweden](#), [Iceland](#), and [Finland](#) while avoiding countries further south in Europe, where power is markedly more expensive. If electricity markets normalize, however, mining could become viable in other European countries as well.

European electricity prices have plummeted over the past year

As you can see in the chart below, electricity prices in most European countries have plummeted over the past year, with spot prices in France, Spain, and Germany falling by more than 50%. Still, the prices in these countries are far from bitcoin mining friendly, exemplified by the current French spot price of \$100 per MWh, which is nearly twice as high as the maximum viable bitcoin mining rate heading into the halving.



Meanwhile, spot electricity prices in NO4 and NO3, the two northernmost electricity price zones of Norway, were on average \$26 and \$39 per MWh in Q2 2023, well within the maximum bitcoin mining threshold. Interestingly, Norwegian miners in these price zones enjoyed even better prices during the European energy crisis in Q2 2022, paying only \$13 and \$26 per MWh in the spot market. Miners in hydro-rich Northern Norway – which has limited high-voltage transmission connection with the European continent – were effectively shielded from Europe’s tumultuous electricity market in 2022.

We see that miners in the two northernmost price zones in Sweden also enjoy relatively cheap, stranded hydro electricity at \$46 per MWh. Swedish miners, including Hive Digital Technologies and Prosperity Digital, were similarly spared from the energy crisis thanks to transmission constraints.

While Norway, Sweden and Iceland have been European mining strongholds for several years, there’s a new kid on the block: Finland. The country recently opened the biggest nuclear reactor in Europe and is estimated to generate around 55% of its electricity from this plant. The massive nuclear influx, along with generally lower electricity prices in Europe, drove Finnish electricity prices down 62% over the past year to the relatively competitive \$47 per MWh. With lots of idle capacity and cheap electricity prices, Finland could over time overtake Norway as the biggest bitcoin mining country in Europe – so long as regulations don’t hamstring development. While electricity prices in other European countries have significantly dropped from the 2022 highs, they are still too high to justify bitcoin mining.

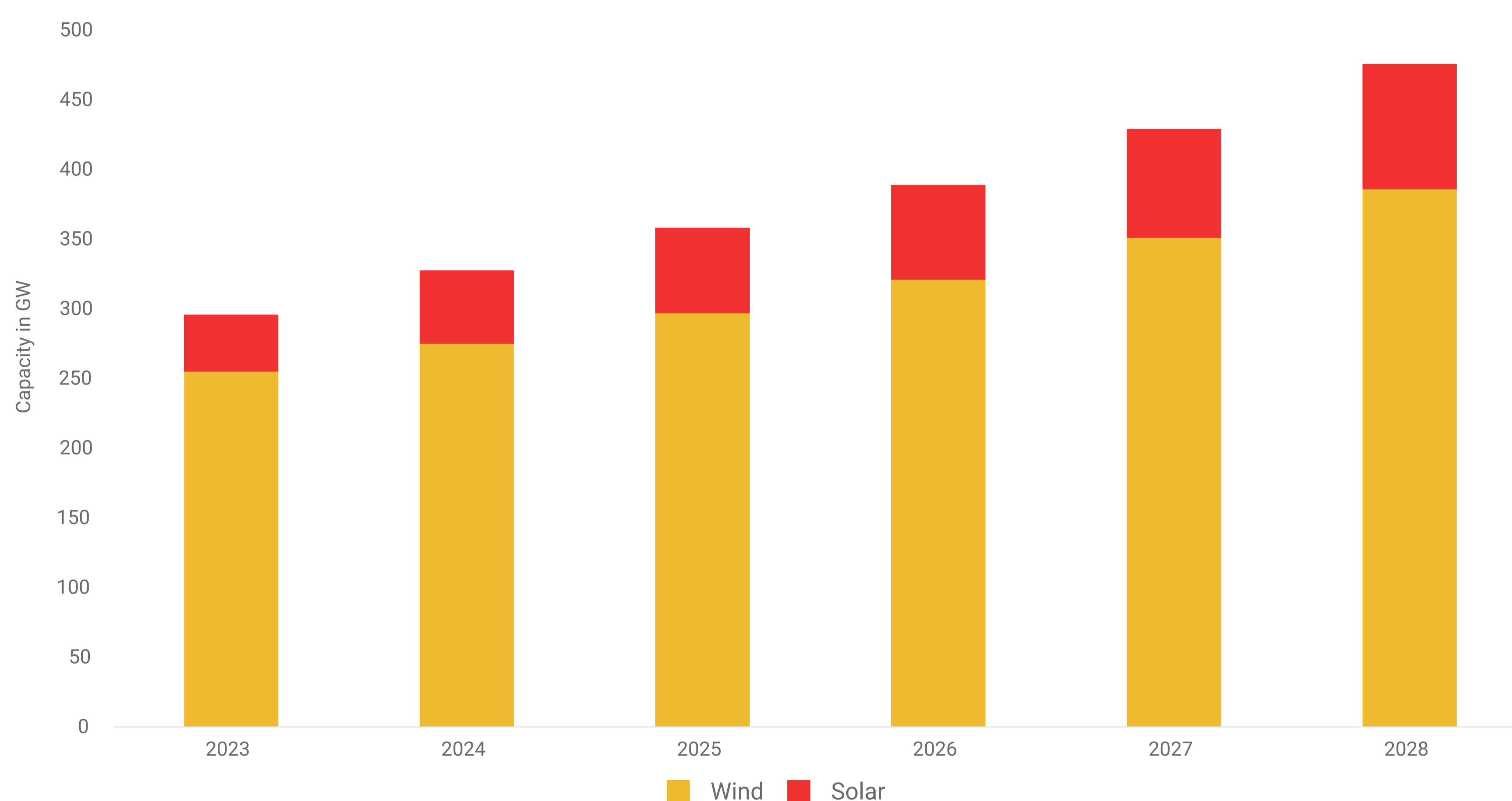
Europe will likely not become a bitcoin mining haven, but we can still hope

It is also highly unlikely that European electricity prices will continue falling. The market consensus is that Europe will keep struggling with its electricity supply in the coming winters, as illustrated by the German electricity futures for deliveries in January 2024 and 2025 trading at \$153 and \$161 per MWh – a considerable increase from the current spot price of \$101 per MWh.

The European energy market is filled with structural problems that could lead to surging electricity prices at any moment. The continent has severely underinvested in baseload generation for many years, leading to a vulnerable electricity market where prices fluctuate wildly according to extreme weather and the caprices of nat-gas rich Russia.

Even if Europe is lucky and again experiences an unusually mild winter, these deep, structural cracks in Europe's energy system won't go away. Therefore, the elevated electricity price risk makes investments in industrial-scale mining facilities unviable in most of Europe, unless the investors can somehow finagle a long-term electricity price hedge OR if prices miraculously fall from today's levels.

Wind and Solar Capacity in Europe: Future Projection



Source: The EU, Wind Europe

Even so, miners and energy producers can utilize smaller bitcoin mining systems to solve various energy problems. For example, Europe's massive commitment to new investment in wind and solar power is already leading to increased electricity price volatility with a growing number of negatively-priced hours. Bitcoin mining machines could be used to soak up solar and wind excess energy when there aren't enough buyers on the grid. For wind, this is usually at night and in the early morning; for solar, it's the early morning.

These smaller, creative setups notwithstanding, Europe's bitcoin mining industry will continue to concentrate on the Nordic, electricity strongholds of Norway, Sweden, Finland, and Iceland.



6

Public Bitcoin miners bounce back

Q2-2023 was a resurrection quarter for the public miners, and that's not really an exaggeration.

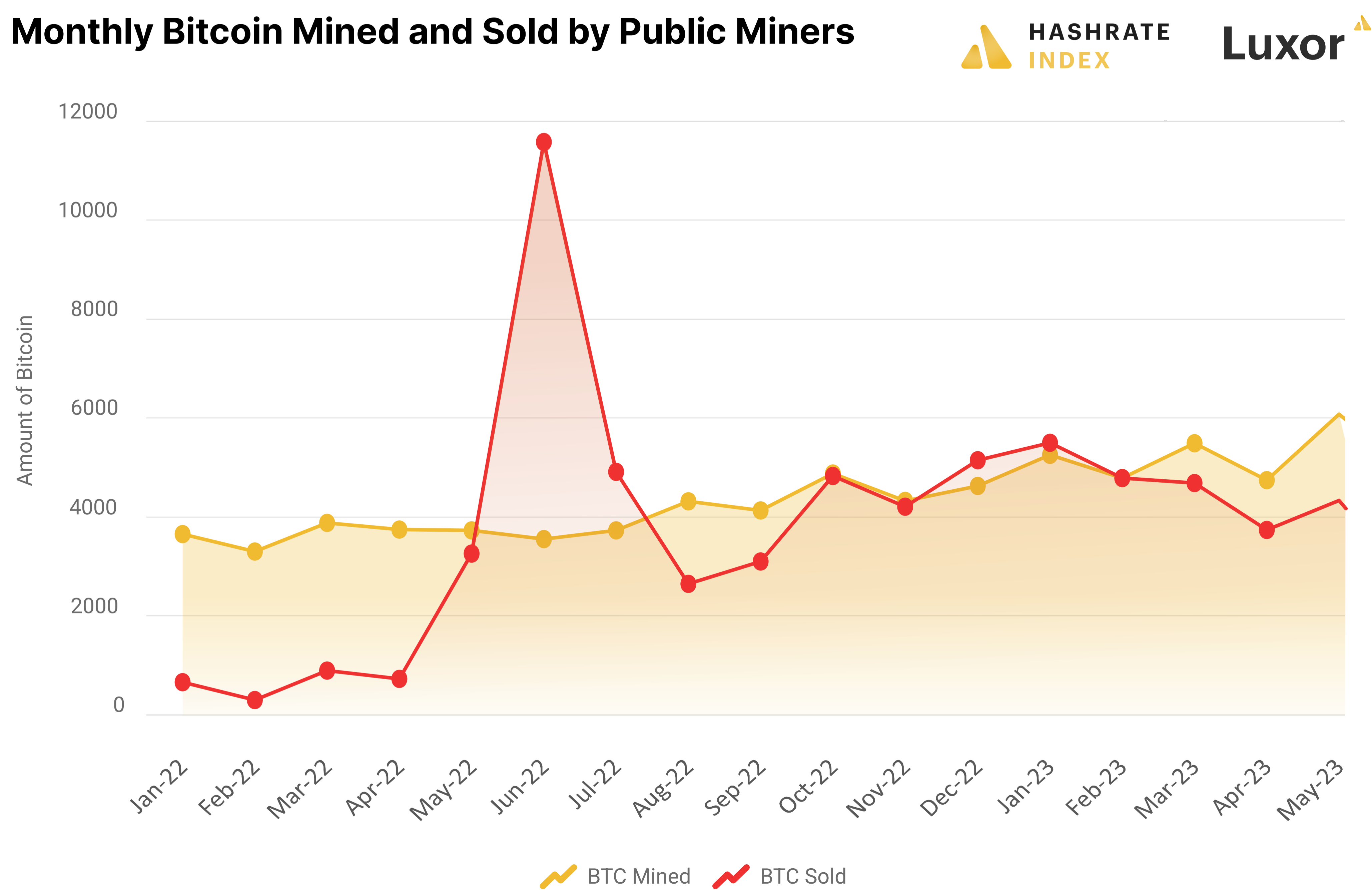
Public Bitcoin miners were brutalized at the end of last year, with stocks losing anywhere between 90-99% of their value over 2022. So far in 2023, many are now up hundreds of percentage points as they rebounded hard from oversold to (arguably) overbought. The stock rally peaked in July but is petering out as we write this report.

We will only cover a limited range of datapoints for public miners in this report and provide high-level commentary. Since these companies will release their 10-Qs for Q2-2023 in August, any data we would report on from Q1 in this report would soon be obsolete. **We will release a stock report for free and premium subscribers in August once the numbers are made public.**

Public Bitcoin miners are selling more BTC

In 2023, public Bitcoin miner production has progressively increased as miners develop new capacity to support expansion and deploy next-gen mining rigs. In the early parts of last year, miners were hodling their Bitcoin stacks and refused to sell. As the fallout from Terra Luna and FTX shook crypto markets and dented hashprice, there was significant forced selling of Bitcoin treasury from public Bitcoin miners. In the bull market, these companies could finance operations with a mixture of debt and equity; in 2022, their equity was worth fractions of their bull market valuations and financing options dried up with the Fed tightening rates. With these two sources of liquidity dried up, public miners sold Bitcoin as they needed, often times at much prices lower than \$30k.

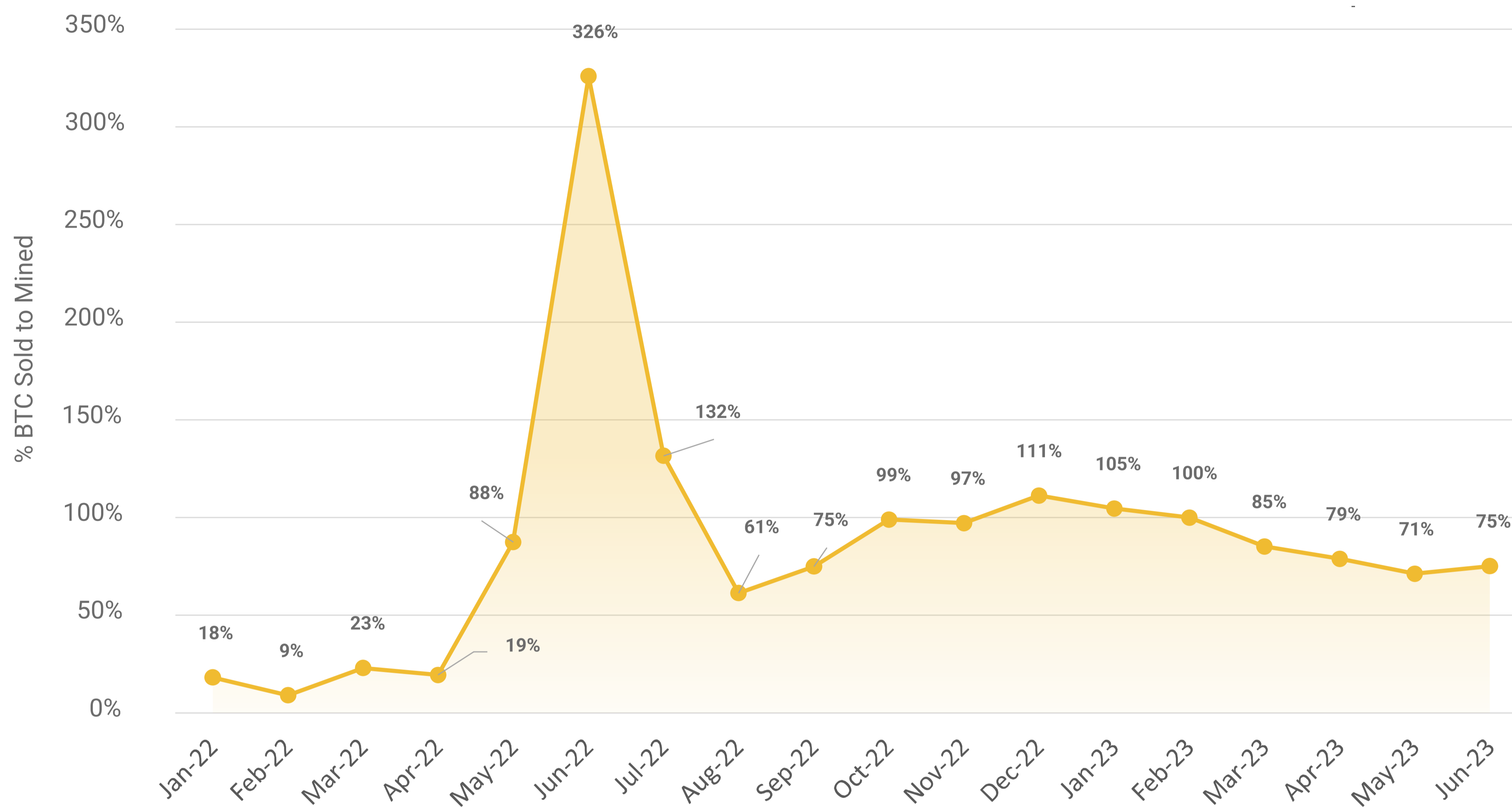
The chart below shows that selling peaked last June, when Bitcoin took its first dive to \$16k. Most of the large selling occurred from highly indebted miners who took on sizable equipment loans when rig prices were at all-time highs or who had other untenable debt.



Source: Public filings, press release, Miner Mag

In the second quarter of 2023, Bitcoin miners increased production massively in the month of May. The fast paced growth in mined capacity was short lived once the month of June arrived. With a large portion of new capacity in Texas and other hot regions of the United States, mining production decreased in June remarkably. In May, public miners produced 6079 BTC; in June, they only mined 4859 BTC. It is clear that the hot summer weather, and higher network difficulty have impacted overall mining efficiency.

Percentage of Bitcoin Sold vs. Bitcoin Mined

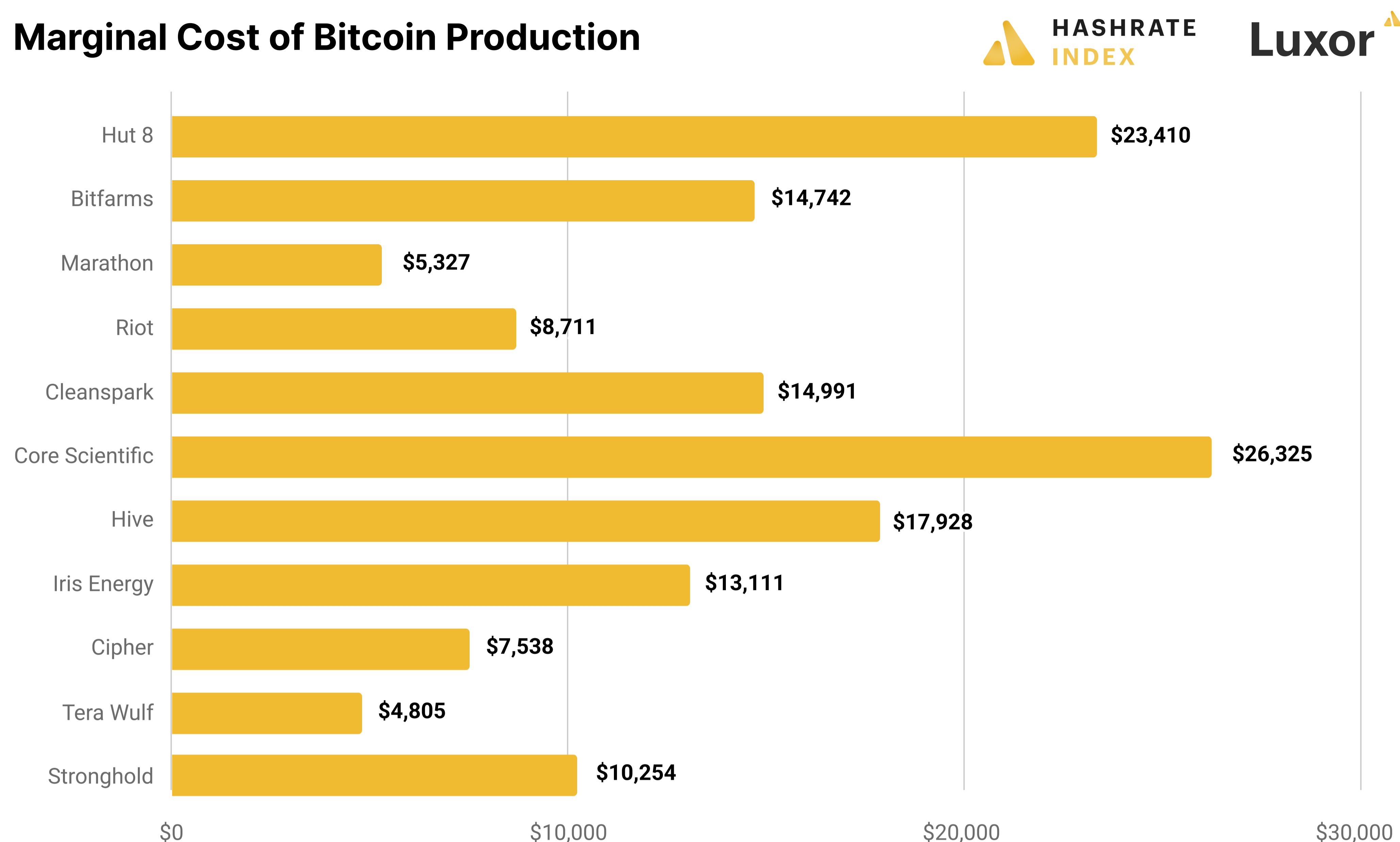


Source: Public filings, press release, Miner Mag

In the first quarter of 2023, miners were selling more BTC on average than in the second quarter. Timing the market is incredibly hard, as you can see from the above chart – the largest amounts of bitcoin were sold during large draw-downs in Bitcoin price. As Bitcoin reached bear market lows during late 2022, the majority of public miners were selling 100% or more of their mined production. As spring arrived, miners adjusted their game plan and most miners started to sell three quarters of their stack every month to fund operations and growth.

We expect that miners will continue to work on their treasury management strategies to avoid making the same mistakes that they did when coin hoarding was the norm in the last bull market.

Public Bitcoin miner marginal cost of production



Source: Public miner disclosure

To arrive at a marginal cost of production for public miners, we take the cost of revenue, excluding depreciation expenses by the number of bitcoins mined during the period. We collected our dataset based on the latest quarterly financials from each company. Based on current mining economics, most publicly traded miners would still produce some mining profit at \$15,000 to \$20,000 Bitcoin.

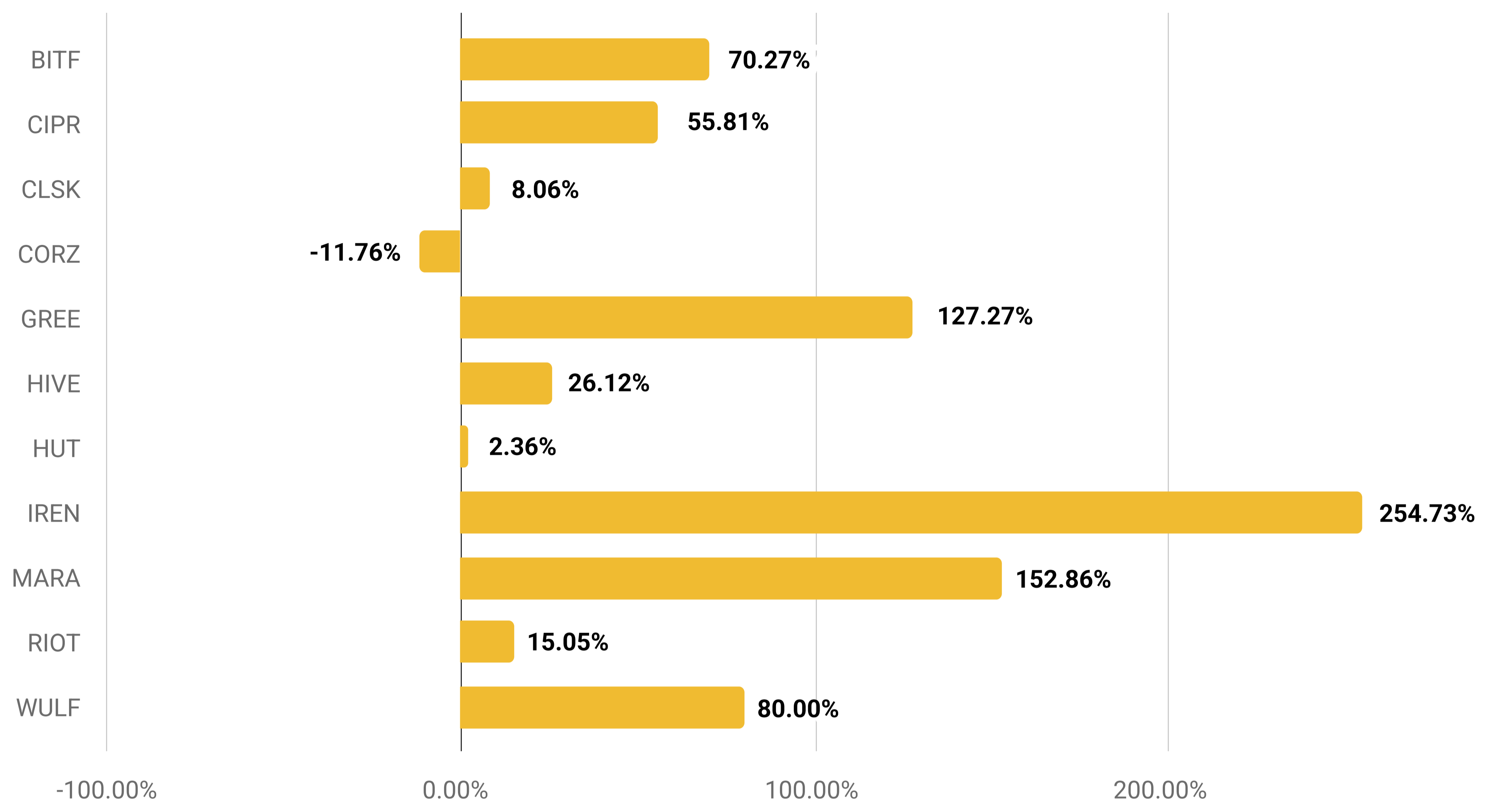
Some key points to highlights within the marginal cost of production, is that we are using first quarter operational input costs to their current mining capacity. Marathon Digital and Terawulf, for example, will likely have a marginal cost of production around \$10,000 once their second quarter financials are released, and other miners marginal costs are sure to increase or decrease as well. We plan to refine this analysis for future reports.

Public Bitcoin miner hashrate expansion

As the first half of 2023 ends, the majority of bitcoin miners have expanded their hashrate. Iris Energy led the pack with a 254% increase in capacity, even after they defaulted on their equipment loan obligations last year. Marathon Digital saw a 152% increase in capacity after their new North Dakota facilities were energized in late spring. Terawulf increased mining capacity by 80% after their Lake Mariner facility became operational in March of this year. Bitfarms increased their operational capacity by 70% as they got approval to energize the full 50 MW at their Argentina datacenter. Greenidge was a dark horse in 2023, as they worked through equipment loan issues from last year and were able to increase capacity by 127%.

We expect to see large continued growth in hashrate among the largest public miners. Cleanspark deployed a huge amount of new capacity in July, growing their June capacity from 6.7 EH/s to over 8.5 EH/s. Marathon Digital will likely see 21-23 EH/s of total capacity from their Garden City energization in August and remaining expansion in North Dakota. Hut 8 will see their hashrate more than double once the US Bitcoin deal closes. Finally, Core Scientific is in the process of restructuring, so expansions won't happen until/if it emerges from bankruptcy.

Year to Date % increased in Hashrate



Source: Public miner disclosures

Don't drink the kool-(AI)d

This industry is no stranger to hype trains and bandwagons, so you could have – and many did – see the hypewave for AI coming.

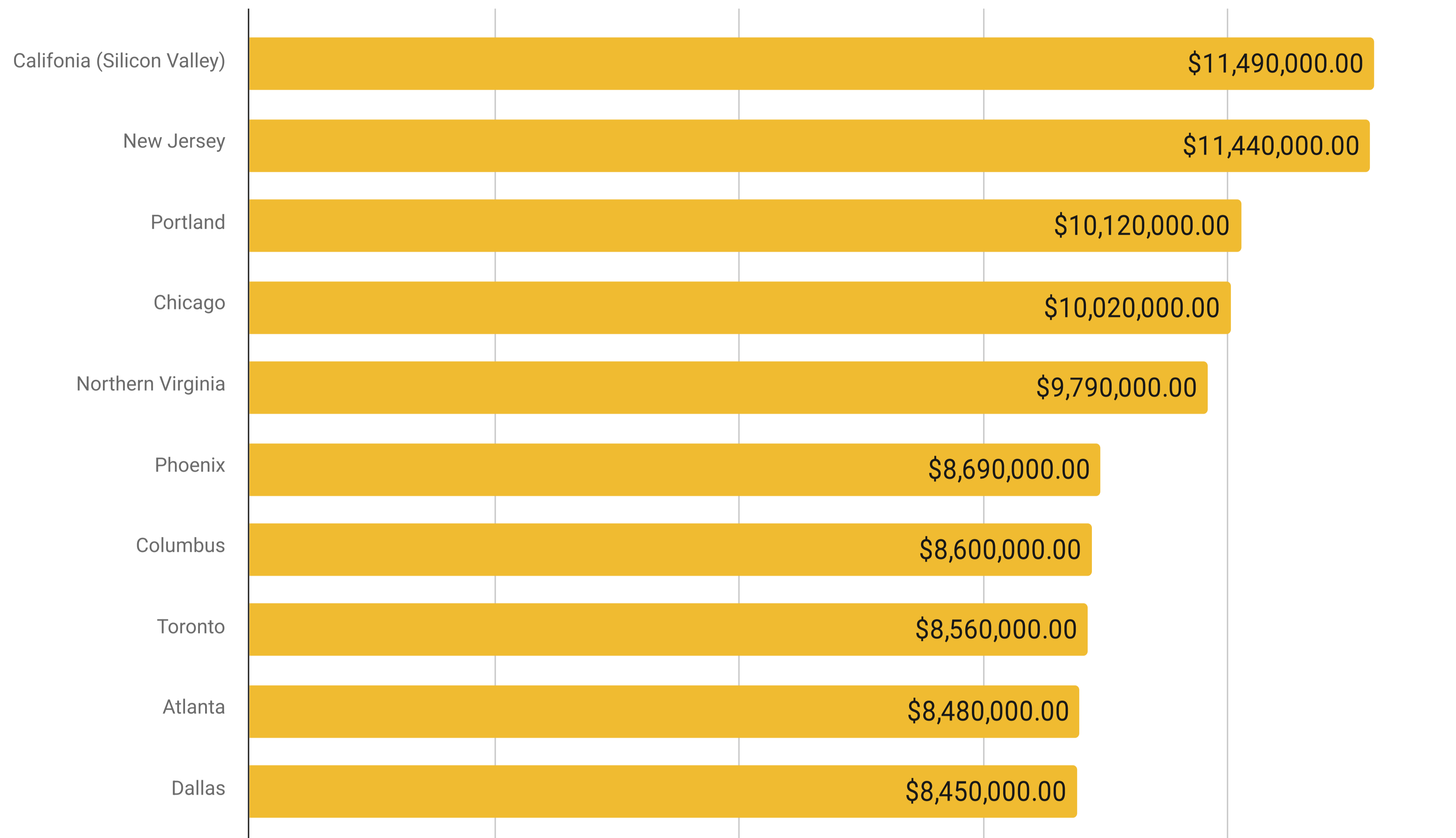
With the advent of ChatGPT, Midjourney, and other AI tools, some miners are capitalizing on the hype by advertising that they can conduct high performance computing and/or AI tasks.

High performance computing is used as a catch all for any number of data center functions. When miners talk about high-performance computing, though, they are specifically referring to things like cloud computing, graphics rendering, and similar high-compute tasks. Hut 8 earned \$4.5 million from such services in Q1, while a pilot program for HIVE generated \$230,000 during the company's financial year ending on March 31, 2023.

Indeed, an AI datacenter could cost anywhere from 10 to 20 times the price per Megawatt than a Bitcoin mine and can cost more than double in power costs to operate (as high as \$0.15/kWh). The computing equipment itself, like Nvidia's A100 and H100 GPUs, costs tens of thousands of dollars per unit. Further, these data centers require vastly more infrastructure for cooling and backup power.

Indeed, an AI datacenter could cost anywhere from 10 to 20 times the price per Megawatt than a Bitcoin mine and can cost more than double in power costs to operate (as high as \$0.15/kWh). Further, these data centers require vastly more infrastructure for cooling and backup power.

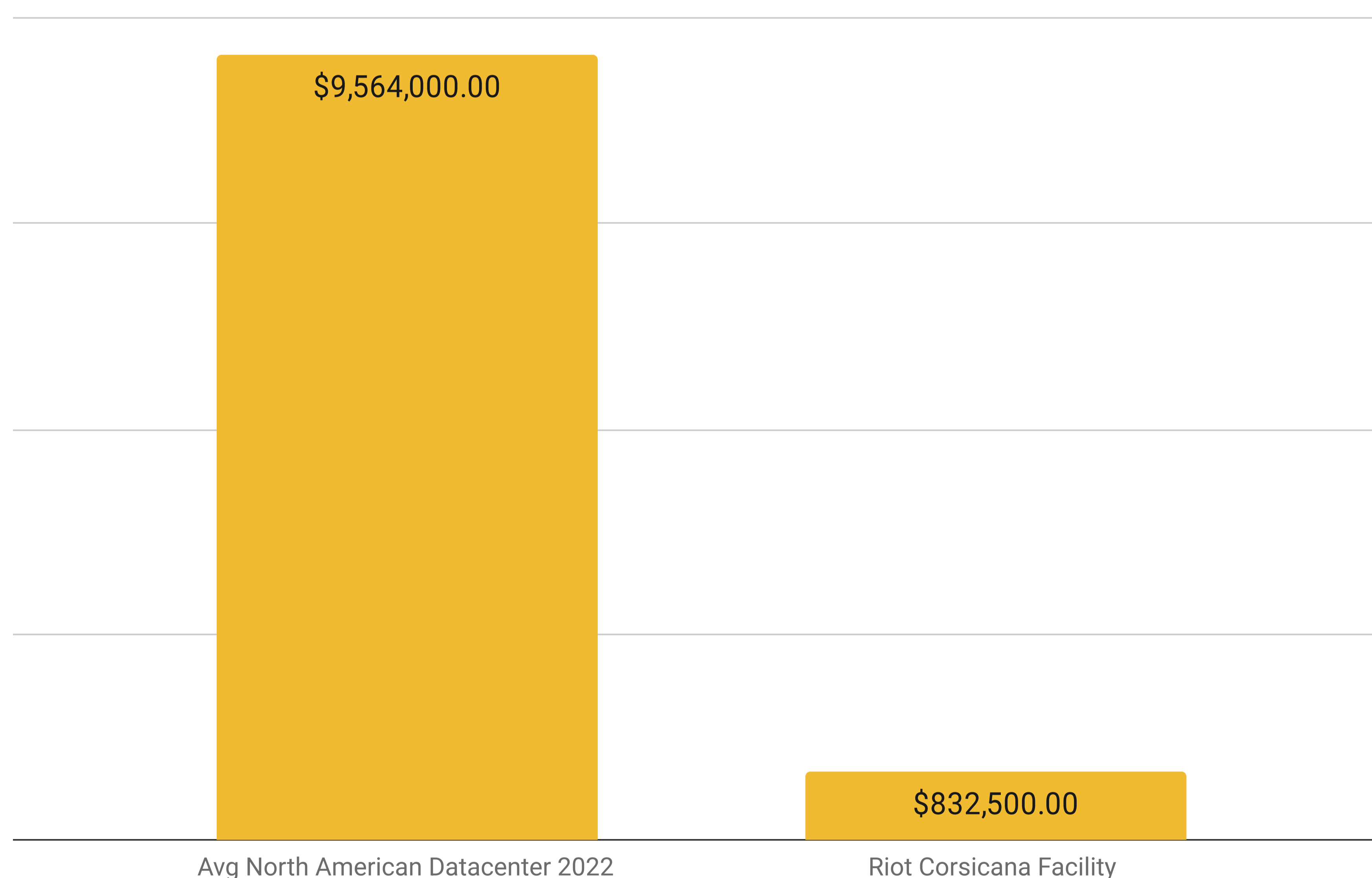
Average Data Center Construction Price per Megawatt (2022)



Source: Turner and Townsend

Riot estimates that its forthcoming immersion-outfitted Corsicana facility will cost \$832,000 per megawatt of power capacity to construct -- \$333 million for 400 MW of total capacity, Riot estimates. Compare this cost to an average calculated from Turner and Townsend's 2022 datacenter index cost: **\$9.5 million/MW.**

Construction Price per Megawatt



Source: Turner and Townsend. Riot public filings

Those that can offer GPU graphics rendering services will, but none of these miners will be employing their computers for Chat-GPT. So don't drink the kool-aid when you see AI in a headline or press release – it's not what you think.



7

Bitcoin mining around the world

In this section we give an overview of the Bitcoin mining landscape in countries with significant or notable mining activity. Since other sections in our report cover the North American market in depth, instead of giving a high-level overview of mining activity in US and Canada, we summarize recent regulatory actions that have impacted the industry.

United States

In the US, 2022 and 2023, broadly speaking, have seen Bitcoin, Bitcoin mining, and crypto generally move increasingly into the real world™. We've especially seen this in the Bitcoin mining industry with regard to traditional capital markets, but we're also seeing it from the regulatory perspective. Q2-2023 delivered some positive developments in that regard.

For instance, much of the ESG pressure that accumulated in the last bull market has dissipated. Public perception – though it's still largely on party lines – is tilting towards acceptance at best and ambivalence at worst for a majority of Americans. The culture war has scarred nearly every socio/economic/political talking point in this country, but for right now, no shots from the culture war have materialized into policy that has seriously injured the sector on the national level.

That hasn't stopped the current Administration and Congress from trying, though. The sector shrugged off a few executive and legislative attempts to impose excess taxes or additional regulatory burdens on the Bitcoin mining sector. Specifically, Biden's DAMEs tax, which would have raised the tax burden for Bitcoin miners as high as 30%, is shelved for now after the deal Congress brokered for the ever-rising debt ceiling. Conversely, the CHIPS act has created a dash for states to find suitable land to seat chip foundries and data centers sites.

With the DAME tax shelved for now, there's nothing to report on the federal level with regards to Bitcoin mining developments last quarter, but there are plenty of actions on the state level to touch on.

Policy action per state

While Federal regulation can have ramifications for Bitcoin miners, individual state regulation has arguably a larger impact. The United State's separation of powers ensures that certain State laws supersede Federal law (Cannabis is one, extreme example of how State and Federal law can be at odds).

2023 has seen a wave of so-called "right to mine" laws from historically conservative states, which typically state that miners can't be discriminated against as long as they are following local and state laws and ordinances. These laws are some of the first to address Bitcoin mining in state legislation and set clear guidelines for regulation.

Other states have pushed neutral-to-negative legislation this quarter and in the past, though most of these attempts have not yet materialized or have fallen through.

Texas

One of the more troubling pieces of legislation came from the US's mining mecca.

On April 12, the Texas Senate passed bill SB1751. A bipartisan group of legislatures in the Texas Senate's Business and Commerce community introduced the bill in March of this year, and among other things, the bill placed limits on the levels of demand response Bitcoin miners in the state could provide, as well as barred them from using certain property tax breaks available to industrial-scale businesses. The bills major sponsors routinely receive campaign funds from energy companies which have invested in peaker plants, a type of natural gas power plant which only operates during hours of peak demand (hence "peaker plant") when the supply of energy can't keep up with demand. Bitcoin mines act as something of a competitor to these plants in their ability to provide the grid with flexible load, and the measures would be a blow to Bitcoin mining industry in the state.

The bill is waiting for the House to cast votes, and many commentators and miners expect it to be shot down.

Arkansas

Arkansas passed legislation to regulate the Bitcoin mining industry as part of its Arkansas Datacenters Act of 2023. The bill-turned-Act 851 stipulates tax breaks for data centers and formally sets guidelines for Bitcoin miners to ensure they can operate in the state so long as comply with:

1. State business law and taxation
2. Local and state ordinances for operations, safety, and sound pollution
3. "Any rule or rate for utility service provided by or on behalf of a public entity and state"
4. State and federal employment laws

Response to the Act has been mixed, with some counties trying to fight it.

Mississippi

In February of this year, Mississippi's Senate passed SB 2603, the Magnolia State's own flavor of a "right to mine." Unfortunately, the Mississippi House shot down the measure in April.

Missouri

In March 2023, the Missouri House and Senate passed the state's own "right to mine" bill, though Governor Parson has yet to sign off on SB 692. Among other things, the bill would ensure that Bitcoin mining farms are given the same treatment as traditional data-centers, and it forbids any state or local legislation that would prohibit residential mining or mining in an area zoned for industrial use; it also exempts cryptocurrencies from state and local taxes. If Parson approves the bill, it would go into effect On August 28 of this year.

Montana

Montana passed a similar “right to mine” bill as Arkansas, which stipulates Bitcoin miners can operate in the state “without being subjected to undue discrimination or requirements.” Governor Gianforte signed the bill into law on May 2, 2023.

Oregon

Oregon lawmakers attempted to push through House Bill 2816 last quarter, a similar effort to Washington state’s bill-now-act to impose emission goals on Bitcoin miners and data centers. The bill failed in committee in April following a massive pushback from Amazon, which is planning 5 new data centers in the state.

Pennsylvania

Pennsylvania House Bill 1476 was stalled in the state’s lower legislative chamber in June. The bill proposed a moratorium on behind-the-meter Bitcoin mining power consumption, and said that it would commission a study on the environmental impact of Bitcoin mining.

The oil rush beginning as it did in Titusville, Pennsylvania, the state has become popular for Bitcoin mining as it’s flush with stranded natural gas wells. It’s also filled with coal, a not insignificant amount of which is considered waste coal.

Washington

Last quarter, the state of Wahsington took a stringent step toward the regulation of data centers and Bitcoin mining farms. Governor Jay Inslee signed Washington House Bill 1416 into law on May 3, 2023. The law places emissions limits on data centers and Bitcoin mines that are in line with green energy goals the state set in 2021.

Canada

Similarly to the United States, Canada has a federated government, and its provinces largely dictate Bitcoin mining regulation. The country of moose, maple, and hockey was the North American leader in Bitcoin mining before the China mining ban washed a bunch of hashrate onto the US’s shores – and before the Canadian state and federal government started tying up the industry in red tape.

Last year in November and December, a handful of Canadian provinces imposed 18-month moratoriums on new mining power contracts, a seemingly coordinated effort to keep miners from growing their footprint in some of Canada’s more energy rich regions. So miners have found it increasingly difficult to expand or break into the Canadian market. None of this even touches on the increase in operational costs imposed by Canada’s federal carbon tax; it’s one of the highest in the world and for natural gas miners would incur a cost of roughly \$30,000 CAD per megawatt.

Notably, electricity imports are exempt from carbon tax, and Canadian power companies export loads of power to the more populous US (Canada's population is 38.25 million, versus the US's 331.9 million, but it has 4 MW of installed capacity for every 1,000 citizens, 19% more than the US's 3.4 MWs per 1,000 citizens). In most cases, power authorities in Canada can make more money selling to US cities than they can to local power consumers like Bitcoin miners.

Finally, Canadian officials have proposed something of a "shadow tax" on Bitcoin miners by barring them (and other data center operators) from receiving input sales tax credits like other exporting sectors.

If the proposal passes, companies engaged in digital asset mining would no longer be eligible to receive Input Tax Credits for the value added taxes paid on mining inputs. This unprecedented proposal would create a hidden tax that increases the cost of Bitcoin mining by 5% - 15%, making Canada a significantly less competitive jurisdiction.

In response, Canadian miners formed the Fair Tax Treatment for Responsible Digital Asset Mining Coalition. They have so far been successful in pausing the proposed changes and have been imploring officials to consult with industry to learn more about digital asset mining, how it works, and how fair taxation and regulation can foster a healthy Canadian digital mining industry.

In addition to the above coalition, the Canadian Blockchain Consortium, a recently formed organization of crypto, Bitcoin, and mining professionals, has been educating policy makers and pushing back on excessive policy.

Alberta

Alberta, ever the Cowboy province, is bucking the nation-wide trend of shutting Bitcoin miners out of power markets.

The oil-saturated province has taken to courting Bitcoin miners at a time when other provinces are turning away. Alberta is a good fit not just for its oil fields, but also for the fact that its energy market is relatively deregulated and a free market compared to state-owned systems like Hydro-Quebec.

While there is no specific legislation in place right now, the government of Alberta has signaled that it wants to push policy that will make Alberta a "modern electricity powerhouse."

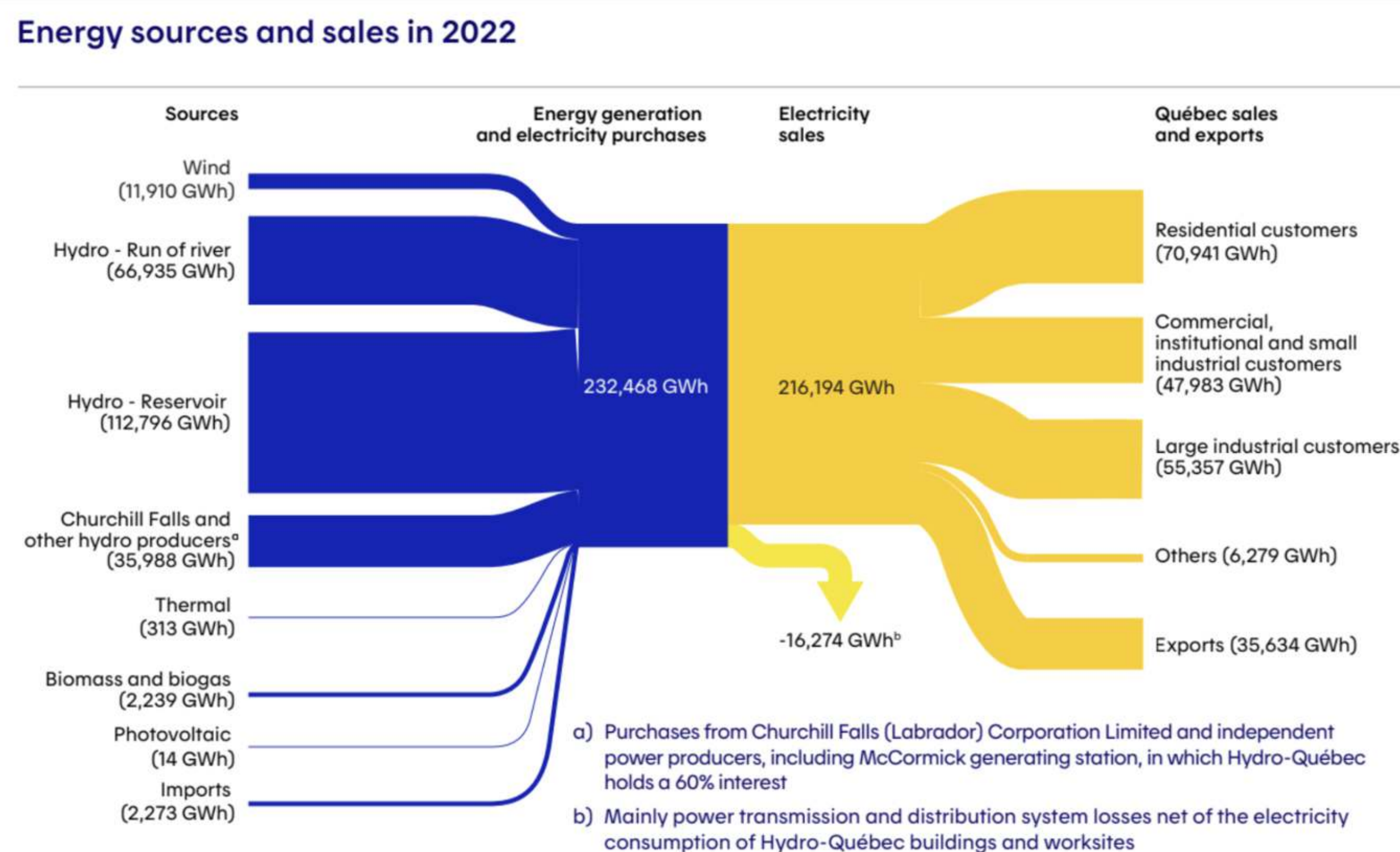
British Columbia

B.C. Hydro, British Columbia's power authority, placed its own 18-month moratorium on Bitcoin mining power contracts in December of last year. At the time, it said that it had received requests from 21 miners for 1.4 GW of power contracts, while it was currently servicing 7 miners for a total of 273 MW of load. This hasn't stopped miners from asking, though.

Quebec

In December 2022, Hydro-Quebec – Quebec’s state-owned-and-operate power company – revoked some 270 MW worth of power contracts it previously awarded to Bitcoin miners. The power authority has a history of imposing stop-and-go moratoriums on new Bitcoin mining contracts, a habit that makes it difficult for new Bitcoin miners to establish in the area. Even those grandfathered in with previous power contracts, such as Bitfarms, have left the province when Hydro Quebec stonewalled expansion plans by refusing to grant new PPAs.

Quebec became an early mining mecca thanks to its abundance of hydroelectric power. It produces so much power, that it exported 16.5% of its production in 2022; per the [power authority’s 2022 report](#), Hydro-Quebec sold 216.2 terawatt hours (TWh) of electricity in 2022, 35.6 TWh of which were exported, mostly to big cities in the US’s Northeast like New York at an average rate of \$0.082/KWh.



Source: Hydro-Quebec

Manitoba

Manitoba enacted an 18-month moratorium on new Bitcoin mining projects in December of 2022.

New Brunswick

New Brunswick enacted a moratorium on new mining contracts in March, 2022.

Newfoundland / Labrador

NewFoundLand and Labrador haven’t taken any actions against Bitcoin miners in the last several years and the joint-province is emerging as one of the most promising mining sectors in Canada.

Latin America and Paraguay

As Bitcoin miners in the western hemisphere look South for cheaper power, Paraguay is emerging as a hashrate leader in Latin America.

In addition to Paraguay, Argentina, Uruguay, and Brazil are emerging as promising mining countries. Columbia and Venezuela also have small pockets of operations, but the lack of economic and political stability in these countries makes it difficult for most miners to stomach the risk, even if power prices are among the lowest available. Importation tariffs can be difficult to navigate.

This section will largely focus on Paraguay as it is the largest Bitcoin mining hub in Latin America.

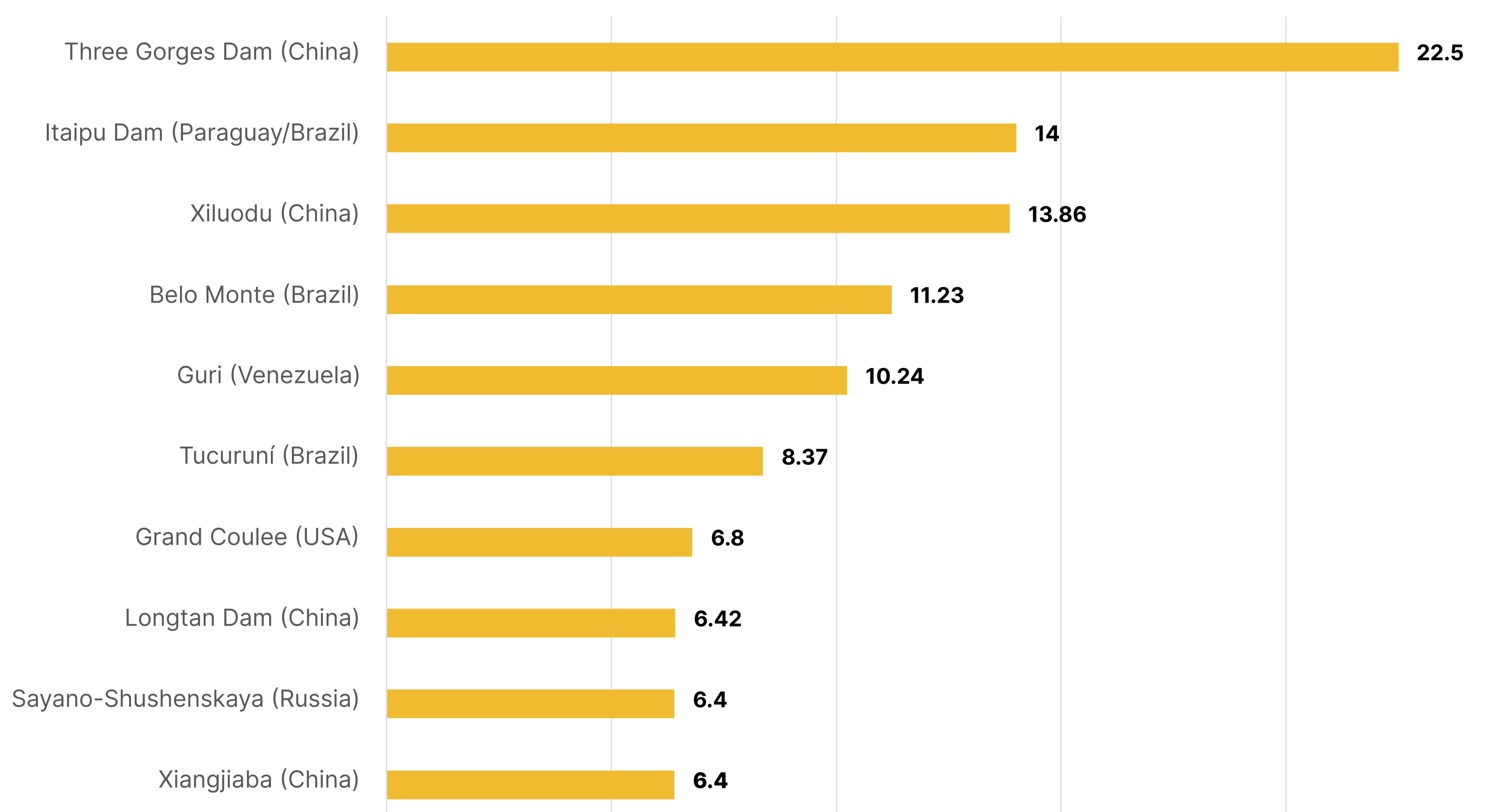
If you'd like to read more about Bitcoin mining in Paraguay, [learn more here.](#)

Paraguay has been on the come-up in Latin America ever since instability in Venezuela, Columbia, and Argentina have deterred miners from setting up shop in these former hotspots. Paraguay is filling a vacuum accordingly thanks to the the Itaipu Dam.

Second only to China's Three Gorges Dam, the Itaipu Dam is capable of generating 14 GW of power. Operational since May 5, 1984, the dam provides power to Paraguay, Brazil, and Argentina, while Brazil and Paraguay co-own the colossus.

Paraguay draws over 99% of its power from this dam and its much smaller cousins, the Yacyretá and Acaray dams. However, Paraguay's population of 6.7 million comes nowhere close to consuming all of the energy its dams produce, leaving it to export 90% of this production to neighboring countries Brazil, Bolivia, and Argentina.

Top 10 Hydro Dams by Capacity (in Gigawatts)



Source: Statista

Paraguay's state-owned power authority, ANDE, is sitting on liquid gold as far as miners are concerned – and they know it. Last year, the Paraguay legislature pushed through a somewhat-pro Bitcoin bill that would formally regulate miners and lower the tariff they pay on electricity. President Benítez vetoed the bill, and Parliament did not reach sufficient quorum to vote on the bill when it returned from the President's desk, so voting is postponed for another year.

Still, miners are undeterred and continue to pour into the country. We've heard rumblings that Paraguay's power authorities are working on at least six 100 MW contracts for industrial-scale miners, some of which are also public miners like Bitfarms.

Bitfarms secured a PPA for 150 MW for “up to 50 MW in Villarrica, in close proximity to the Company's existing operations in Paraguay, and up to 100 MW in Yguazu, a new location close to the Itaipu dam [and] the third largest hydroelectric dam in the world.”

Paraguay is no doubt an attractive location for mining, but miners need to have the right connections to navigate Paraguay's somewhat complicated permitting and registration. Bitcoin miners have to establish an LLC to bulk import Bitcoin mining hardware, and they have to put money down on a power warranty for their PPAs. They also need a permit to import cables and other electrical equipment needed to sustain a mining operation. Importation fees for mining rigs can cost anywhere from 17-20% of a machine's market value (which is actually a steal when you compare it to the 50-80% tariff miners pay to import machines into Brazil and Argentina, or the excess bribes needed in places like Venezuela and Columbia). Additionally, miners need a permit from the Ministry of Commerce to build a Bitcoin mine, but this permit can be acquired in a few days. Finally, Bitcoin miners have to pay an environmental tax to stay compliant.

Barring any drastic action from the government or general socio-political instability, we expect Paraguay to cement itself as the seat of mining in Latin America in the years to come.

Bitcoin mining is becoming an increasingly accepted industry in Russia

Until recently, the Russian bitcoin mining industry has grown and operated in the same manner as the mining industry in most countries - in an unregulated, wild west fashion. However, recent discussions between Russian miners and different ministries indicate that the Russian government is looking to regulate the industry.

Both the Ministry of Energy, the Ministry of Finance, and the mining industry itself, are pushing for industry regulation. Regulation will provide three main advantages for the mining industry and relevant regulatory bodies.

First, it will establish a tax regime that will define how much miners should pay in taxes and to whom it will pay. Secondly, it could simplify the corporate structure of Russian miners, as Russian miners currently cannot self-mine through a Russian entity due to bitcoin revenue not being accepted in the current accounting laws. Third, and perhaps most importantly, regulation would make the industry more attractive to investors, opening up for public listings of miners on the Moscow Stock Exchange as well as allowing them to raise debt. Many Russian investors and financial institutions want to get exposure to mining but are, understandably, putting investments on hold until the industry is regulated.

Another interesting aspect of the upcoming mining regulation is that it might outlaw or severely restrict home mining. As we soon will explain more, home mining has led to problems with the distribution network in certain Russian cities. Due to the resulting poor PR image of mining, the industry, led by Igor Runets, the BitRiver CEO, is pushing for home mining restrictions.

However, such comprehensive regulation is not implemented overnight, particularly considering that different government bodies, like the Ministry of Energy, the Ministry of Finance, and the Russian Central Bank, have different opinions on how to proceed. For example, while the Ministry of Finance wants that miners pay extra taxes on their profits, the Ministry of Energy suggests that miners pay zero corporate taxes or VAT, but are instead heavily taxed based on their electricity consumption. One thing seems to be certain; Russian miners will likely see their taxes increase when the industry gets regulated, either in form of extra corporate taxes or electricity taxes. The Russian government expects to have the bitcoin mining regulation in place sometime in 2024.

Even after the massive growth over the past two years, bitcoin mining is still a miniscule industry in Russia compared to for example oil and gas or conventional mining. However, the Russian government still appears to pay close attention to the emerging industry, likely due to its possible future strategic importance.

One of the highlights from the St. Petersburg International Economic Forum was the Ministry of Finance explaining how the Russian government plans to strategically use mining as part of its domestic and international payment schemes. The idea is that miners will have to sell their mined bitcoin to Russian banks in exchange for the digital ruble - the Russian CBDC. Thus, miners will help put the digital ruble into circulation as well as giving bitcoin liquidity to the Russian Central Bank.

The Russian banks will, in close cooperation with the Russian government, use this bitcoin for international transactions, most likely to bypass sanctions. This strategy is similar to that previously deployed by the Iranian government.

Kazakhstan

Over the past year-and-a-half, a Kafkaesque bureaucratic process has reduced Kazakhstan's once great bitcoin mining industry to a shadow of its former self. Having been partly cut off from the grid since late 2021, Kazakh miners were hoping that the new comprehensive bitcoin mining regulation implemented on April 1st would provide more regulatory clarity and better operating conditions. However, it doesn't look like things have improved.

Read [this article](#) if you want to learn more about mining in Kazakhstan.

The Nordics

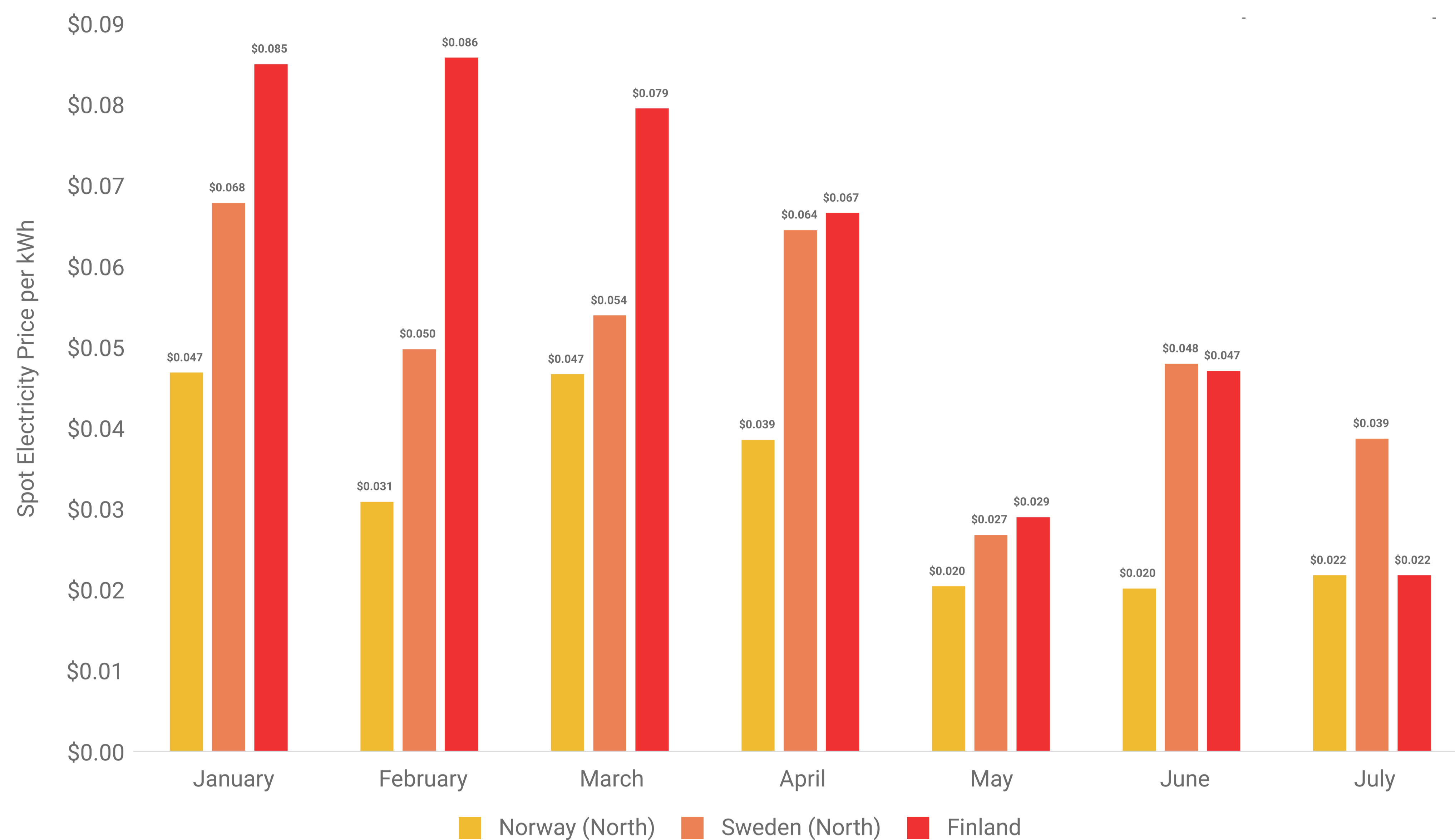
The Nordic countries of Norway, Sweden, and Iceland have for many years been among the most favored destinations for bitcoin miners in Europe due to their attractive combination of cheap, renewable energy and a relatively simple business environment. Recently, Finland also joined the ranks of its neighbors as an attractive bitcoin mining country due to its electricity price drop. In this section, we will summarize the most significant trends and recent happenings in Nordic bitcoin mining.

Summer means low electricity prices for the Nordic miners

The main selling point of bitcoin mining in the Nordics is the stable, low electricity prices fueled by abundant hydropower from the northern parts of Norway and Sweden. How did the electricity prices in this region develop so far in 2023?

All the Nordic countries, except for Iceland, have deregulated electricity markets, making it simple to compare historical spot prices. As you can see on the chart below, electricity prices in these countries in 2023 have been very low compared to those of European countries further south. Northern Norway, as usual, has seen the lowest electricity prices in Europe this year, with monthly average spot prices staying between \$0.020 and \$0.047 per kWh.

Average Spot Electricity Prices in 2023 in the Nordic Countries



Source: Nordpool

Although not matching the exceptionally low prices in Northern Norway, bitcoin miners in Northern Sweden also have access to highly competitive electricity rates on a global basis. In 2023, the monthly average spot electricity prices in the northernmost electricity price zone of Sweden have ranged between \$0.027 and \$0.068 per kWh.

Meanwhile, Finland, which was heavily affected by the energy crisis, has seen a drastic and consistent reduction in electricity prices so far in 2023, with the average price in July dropping to \$0.022 per kWh.

We don't have data on electricity prices in Iceland since the market follows a utility structure where the bitcoin miners must negotiate a power purchase agreement directly with the local utility company. However, due to the extreme strandedness of this volcanic islands' hydro and geothermal resources, we have no reason to believe that electricity prices have significantly changed in Iceland recently.

As we also can see on the chart, electricity prices in all the Nordic countries have consistently fallen since January. This phenomenon is completely normal in this region due to two reasons. Firstly, the gradually warming temperatures lead the heating demand to significantly decline. Secondly, the supply also increases tremendously as melting snow in the mountains of Norway and Sweden leads to massive hydropower production.

We expect electricity prices in the Nordics to stay at exceptionally low levels at least until November, when the cold weather will lead to lower hydropower production and higher heating demand.

Read [this article](#) if you want to learn more about mining in Finland, [this article](#) if you want to learn more about mining in Sweden, [this article](#) to learn more about Bitcoin mining in Iceland, and [this article](#) to learn more about mining in Norway

We expect the geographic diversification narrative to keep strengthening, and wouldn't be surprised to see other public miners expanding into the Nordics.

The Middle East

The Middle East has quickly emerged as one of the fastest-growing bitcoin mining regions. We are here primarily talking about the GCC countries of the Arabian Peninsula, consisting of the United Arab Emirates (UAE), Saudi Arabia, Kuwait, Oman, Qatar, and Bahrain.

The Luxor team recently spent some weeks in some of the above mentioned countries to better understand the mining potential there. We were not disappointed with our findings. These countries have massive bitcoin mining potential due to their abundant energy resources, business friendliness, and a strong willingness to continuously modernize their economies.

Why the Middle East will become a great bitcoin mining region

Bitcoin mining matches perfectly with these countries' electricity systems. In these hot and dry countries, up to 70% of the energy consumption goes to cooling and freshwater production. However, temperatures can vary tremendously between the hottest and the coolest months, leading to enormous seasonal fluctuations in electricity consumption by all the air conditioners. Due to this consumption pattern, the base demand in the winter is approximately half of the peak summer demand.

Such seasonal fluctuations naturally put strains on the electricity system. To make the situation even more challenging, the power plants cannot reduce their output during the winter to accommodate the lower demand. The reason for this is that these countries use combined power and desalination plants to desalinate seawater. Due to the critical necessity of delivering freshwater, these plants must run at a relatively continuous capacity throughout the entire year, even though the electricity demand fluctuates tremendously between the hottest and coldest months. This leads to enormous amounts of wasted electricity.

Bitcoin miners can provide a much needed baseload to these electricity systems and monetize the excessively generated electricity; stabilizing the grid and increasing the utilities' revenues.

Historically, virtually all the electricity consumption of these countries has come from natural gas. However, in recent years they have been adamant in diversifying their electricity supplies with other sources like nuclear, wind, and solar. The UAE recently opened the biggest nuclear power plant in the Arab world at 5.4 GW and also plans to build the world's largest solar plant at 5 GW by 2030. Other countries in the region also have similar plans for expanding their electricity generation capabilities, with Saudi Arabia having the potentially most ambitious plans.



The Mohammed bin Rashid Al Maktoum Solar Park | Source: [DEWA](#)

Asia

Until 2021, China was the seat of the Bitcoin mining industry, with anywhere from 50-70% of Bitcoin's total global hashrate.

Now, mining hasn't totally left China, and the country is still the dominant player on the Asian continent. But the exodus from China following the Bitcoin mining ban means that hashrate has spilled over into neighboring countries.

We will touch on a few of these countries in this section, while giving a quick update on what's happening with the Chinese mining community.

China

The CCP rolled out a coordinated province-by-province ban of Bitcoin mining in the summer 2021, but they didn't totally quash the industry. We estimate that as much as 20% of hashrate could still be in China.

Indeed, miners with political connections – or those with the balls to operate in the shadows without preferential treatment – still hash in the region, with the dams in the Szechuan region and elsewhere still acting as the center of gravity for most mining activity.

During the rainy season (May - September), miners can secure power at a rate of \$0.03-0.035/KWh. Most all of these operations are small scale (1-2 MWs) as the practice is still formally banned in the country.

When China dominated the Bitcoin mining game, it was difficult for onlookers in the West to get a peep into the Chinese Bitcoin mining scene, and the same is true today. What we do know is that the scale of the farms is much smaller now than it was before the ban, and that those miners who are still operating typically have close ties with CCP officials and are of a privileged class who are allowed to operate within certain parameters.

We anticipate that this remnant will remain in China and that a sizable portion of Bitcoin's hashrate will continue to come from the country for the foreseeable future.

Bhutan

This quarter, the DHI, an investment arm of the Bhutanese government, finally confirmed that they have been using their stranded hydroelectric power to mine bitcoin for several years. The veteran nation state miner allegedly started mining when the bitcoin price was at only \$5,000. Now, after going public with their operation, the mountainous country wants to take it to new heights.

Bhutan recently announced that they have made an agreement with Bitdeer to expand their bitcoin mining capacity to 600 MW within three years, with the first project stage of 100 MW launching in September. Bitdeer is currently raising \$500 million from international investors to fund the project.

There are several reasons why bitcoin mining makes sense for Bhutan. Most importantly, with its massive hydropower resources, Bhutan has more electricity than it knows how to deal with. Historically, the country has exported most of its excess hydropower to India. However, relying too much on one industry and one trading partner is highly risky and gives Bhutan little leverage in negotiations with India. Thus, Bhutan could diversify its economy and refine its hydropower into higher value by using it to mine bitcoin within the country, instead of just exporting it to India.

Bhutan currently has 2.4 GW of hydropower capacity but plans to open two new power plants within the end of 2024 at a combined capacity of 1.4 GW. This capacity growth further increases the country's electricity surplus which it can use to mine bitcoin. With Bhutan and El Salvador leading the way in nation state bitcoin mining, we expect other countries to follow suit within the next couple of years.



8

Final Word: 2024 halving and hopium

As Bitcoin miners approach their fourth Halving, the game is changing at a rapid pace. Hashrate is spreading into new geographies, power management strategies are maturing, miners are unlocking new pools of capital and financing, and the scale of the industry has never been larger.

It's hard to imagine what the Bitcoin mining landscape will look like when this next Halving epoch comes to a close. But we do expect to see some serious hashrate restructuring once the block reward drops to 3.125 BTC as higher cost operators become unprofitable and drop off the network. By the same token, we anticipate further hashrate growth in burgeoning mining regions like Latin America, the Middle East, and Russia in the epoch to come as miners search for low-cost power.

That's not to say that North America won't retain a significant share of network hashrate. Just that, given a low enough hashprice environment, miners of all sizes will start looking for opportunities elsewhere.

Some Bitcoiners -- and miners among them -- subscribe to the theory that Bitcoin's price runs are incited by the Halving's inflation reduction. Miners should be careful to bet on bull market price action for their base case going in to 2024. In our opinion, miners with \$0.075/KWh should be evaluating their post-Halving strategies and seek ways to boost machine efficiency with firmware, seek lower power costs, or reduce other operational costs.

The best time to plan for the Halving was when this current epoch began on May 11, 2020. But now is as good of a time as any for miners to prepare, and if they can't lock in low-cost PPAs or hosting agreements, then it's time to get creative. Hedging strategies for both both power and hashprice will be crucial for navigating the coming years.

Anything could happen to Bitcoin's price between now and after the Halving, so it's wise to consider multiple scenarios when modeling out the future.

May the luck be in your favor.

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