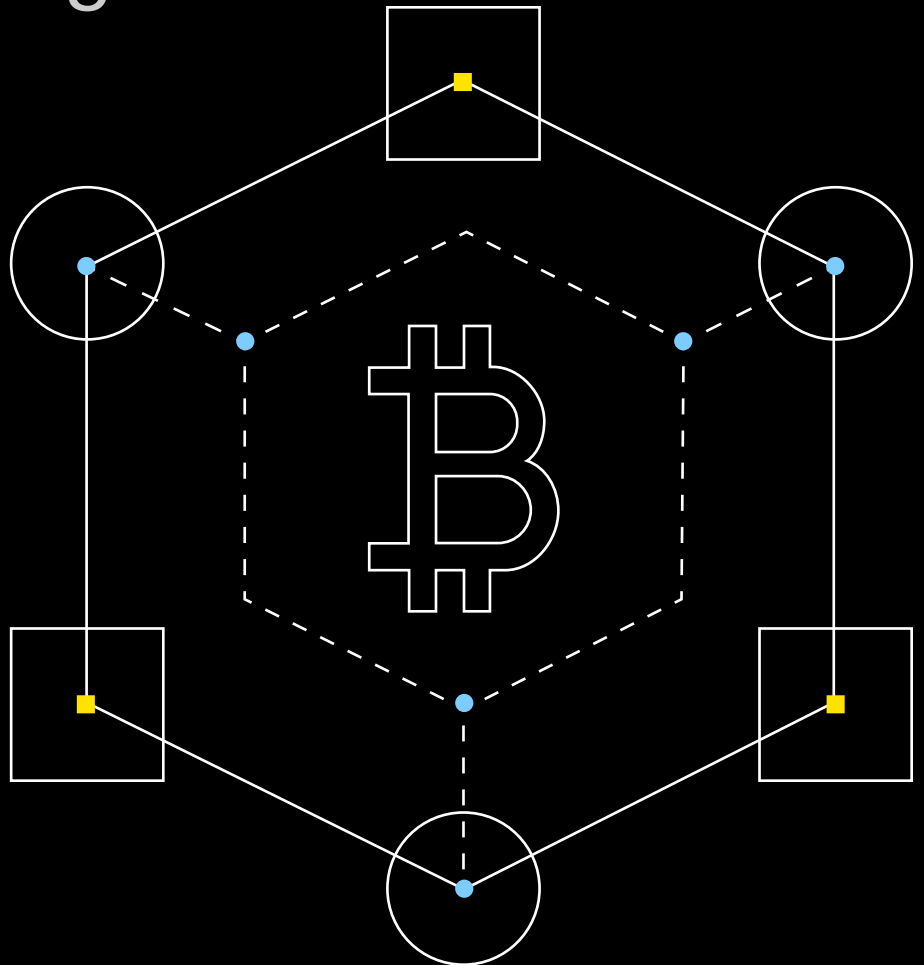galaxy

Galaxy Research

2024 Bitcoin Mining Mid-Year Report

The Rise of the Gigawatt

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Introduction

The first half of 2024 was a pivotal period for the Bitcoin mining industry, marked by significant economic shifts and evolving market dynamics. Miners faced a rollercoaster of economic changes, starting the year on a strong footing until Bitcoin's 4th halving event, where hashprice subsequently dropped to all-time lows. Despite these fluctuations, large miners have remained resolute on their growth trajectories and the depressed post-halving economics spurred a flurry of Mergers & Acquisition ("M&A") activity in the space as miners sought to consolidate and benefit from scale.

Moreover, the convergence of trends in Artificial Intelligence ("AI") and High-Performance Computing ("HPC") with Bitcoin Mining has presented miners with an opportunity to allocate capacity to satisfy the emergent and ongoing exponential demand curve in AI/HPC. As suggested by the title of the report, the value of a Gigawatt has grown significantly as competition has grown fierce for access to land and power by bitcoin miners, hyperscalers, and others. Those with a near-term path to energization are uniquely positioned to capitalize on trends in both industries.

In this report, we delve deeper into the changing landscape in Bitcoin mining, starting with an overview of the current state of mining economics, and then expanding on key post-halving themes, such as the evolving capital markets landscape, the immense demand for power capacity, the uptick in M&A activity, and the forecasted growth in hashrate for the second half of the year.

Key Takeaways

- From its peak level at 88.1 T (630 EH implied hashrate), **difficulty dropped 10%** to a post-halving low of 79.5 T (569 EH implied hashrate) in early July as hashprice hit all-time lows. As of writing, difficulty stands at 82.0 T (587 EH implied hashrate).

- In Q1 2024, **the public miner peer set raised a combined $1.8 billion in equity capital**, marking the highest amount raised in a quarter in the past 3 years.

- While miners have resorted to equity issuance in recent months for capital raising, **we expect to see debt capital markets reemerge in H2 2024 and into 2025** as the value of available power capacity skyrockets.

- **Miners that are approved for large scale power capacity, that have procured long-lead time infrastructure, and that have access to water and fiber are optimally positioned to capitalize on the AI revolution.**

- In our Annual Report, we estimated a range of 675 EH to 725 EH for our end of 2024 hashrate target. **We are now revising our growth upwards to between 725 EH and 775 EH**, using a combination of public miner information, seasonality trends, and profitability analysis.

- From January 1, 2024 through July 23, 2024, Bitcoin miners generated 12.97k BTC ($863 million as of July 23, 2024) in transaction fees. Miners have earned roughly 55% of the total fees accrued in 2023 (23.4k BTC).

- Year to date, **over $460 million has been transacted across various deals**, primarily categorized into site sales, reverse mergers, and company acquisitions. We expect M&A activity to continue in the industry going forward.

State of the Market

Mining Economics H1 2024

The first half of 2024 was very much a tale of two quarters. In Q1 2024, miners enjoyed some of the best economics over the past two years. Hashprice averaged $0.094/TH for the quarter, propelled by the rise in bitcoin price. Hashrate continued its steady climb during the quarter to offset some of the increases in bitcoin price. The robust margins in Q1 2024 were needed to build cash balances before Bitcoin's 4th halving in Q2 2024.

Mining economics in the second quarter remained strong until Bitcoin's 4th halving. At the halving, the much-anticipated Runes launch caused transaction fee fireworks for a few days. In the week following the halving, miners generated significant transaction fee revenue, which we dive further into in the next section.
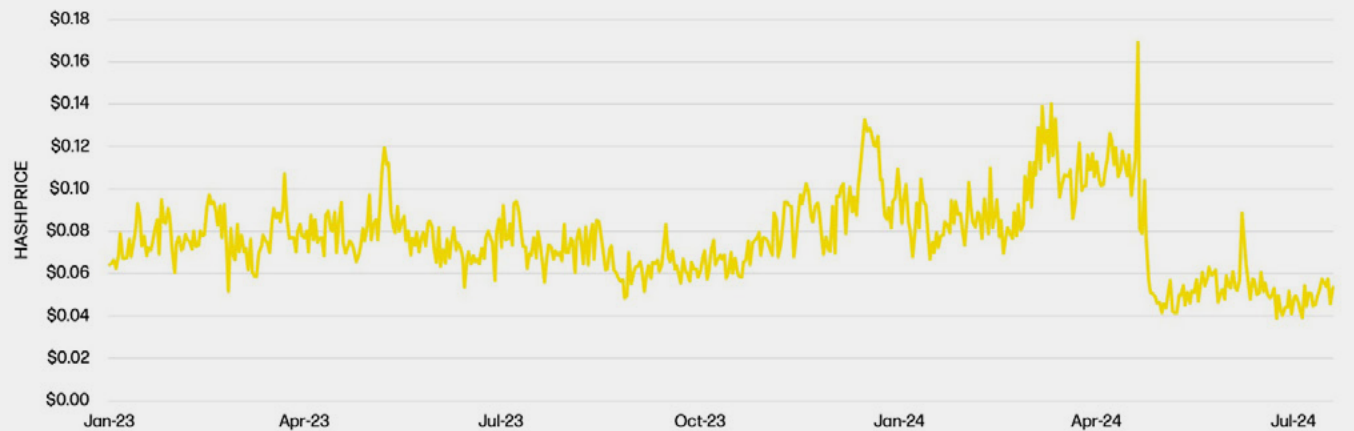
Bitcoin Price and Transaction Fees
Source: Galaxy Research
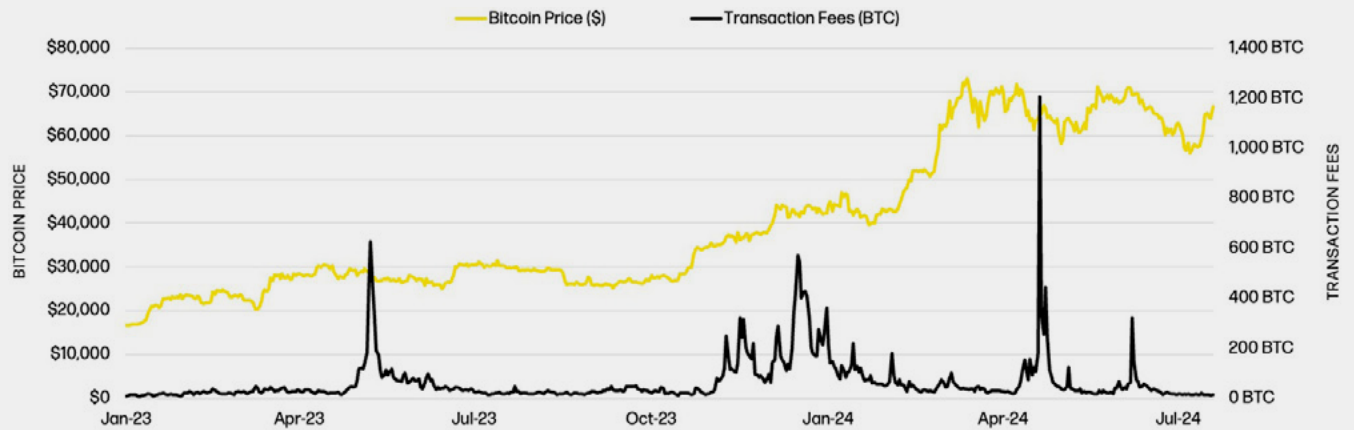
Data: Coinmetrics

Hashprice
Source: Galaxy Research

Data: Coinmetrics

The transaction fee surge pushed hashprice up to $0.17/TH for a very brief period, reversing the impact of the reduction in block subsidy. Recall that hashprice is miners' preferred metric for distilling all-in revenue per terahash of computing power per day. However, the spike was short lived and hashprice subsequently hit all-time lows following the stabilization of transaction fees. Hashprice has averaged $0.054/TH since the halving.

From its peak level at 88.1 T (630 EH implied hashrate), difficulty dropped 10% to a post-halving low of 79.5 T (569 EH implied hashrate) in early July as hashprice hit all-time lows. At the time of writing, difficulty stands at 82.0 T (587 EH implied hashrate).

At current hashprice levels, a meaningful proportion of the network is still profitable, but only marginally. Some miners on the fence may continue to operate because they can generate positive gross profits. However, when factoring in operating expenses and additional cash costs, many miners find themselves unprofitable and slowly running out of cash. The strong economics of Q1 2024 helped build cash balances, which prolonged runways for inefficient miners. Without a meaningful rise in bitcoin price or transaction fees, we expect that miners on the cusp of profitability to drop off the network if hashprice declines further.

Even if that happens, the downward pressure on network hashrate due to unprofitable miners turning off machines will be more than offset by the energization of new generation Application-Specific Integrated Circuits ("ASICs"). New generation machines have nameplate hashrates that are more than double the previous generations' hashrates. Seven of the top ten public miners by market capitalization collectively have projected an additional 109 EH to be energized in the second half of 2024. As we analyze at the end of the report, despite the recent halving, we believe hashrate will rise materially in H2 2024. Without an increase in bitcoin price, this will add headwinds for miners.

Transaction Fee Volatility

Since January 1, 2024, Bitcoin facilitated over 99m transactions on-chain. Of the 99m transactions, 50% were standard transactions, which we define as financial transactions. Runes, BRC-20, and Ordinal transactions represented 35%, 11%, and 4% of transactions respectively. The 35% market share of total transactions from Rune related transactions is significant when considering that the fungible token protocol launched on April 19, 2024. Since their launch, Runes represent an average of 63% of all transactions on Bitcoin.
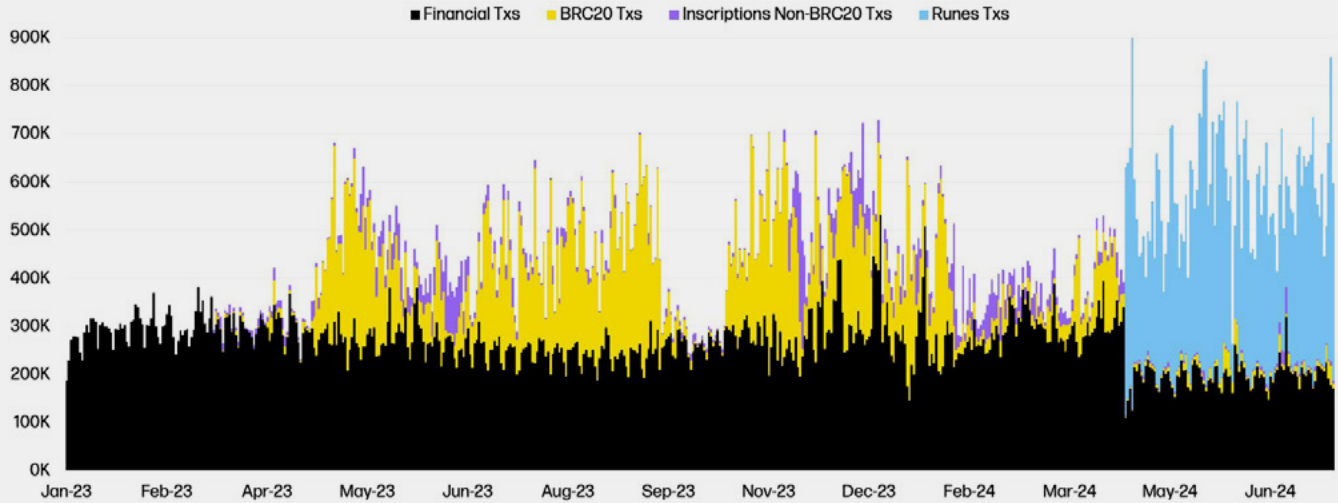
Network Difficulty and Hashrate
Source: Galaxy Research
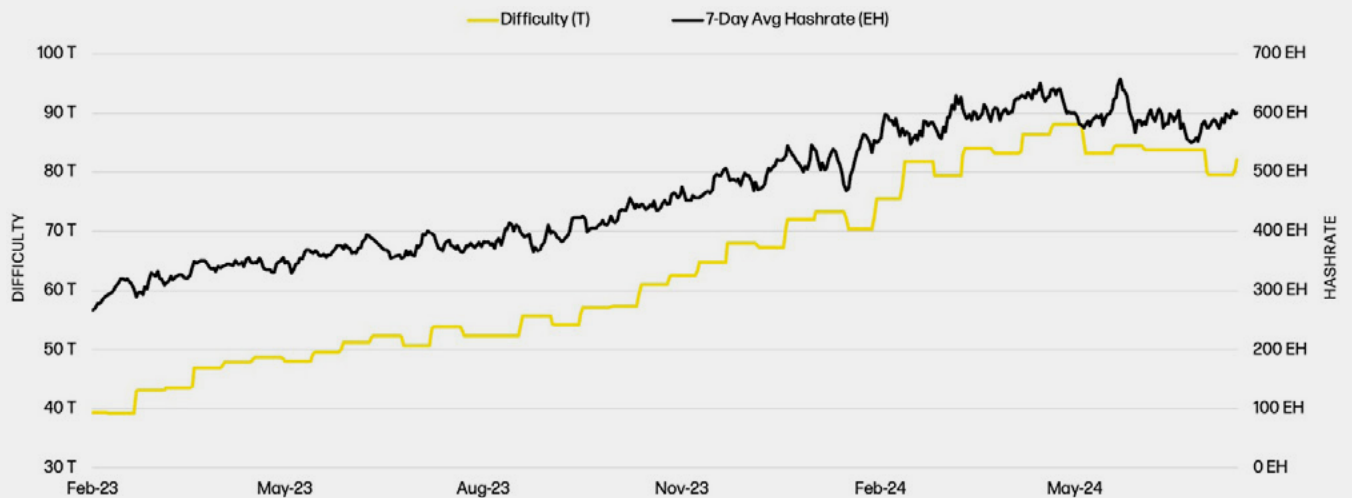
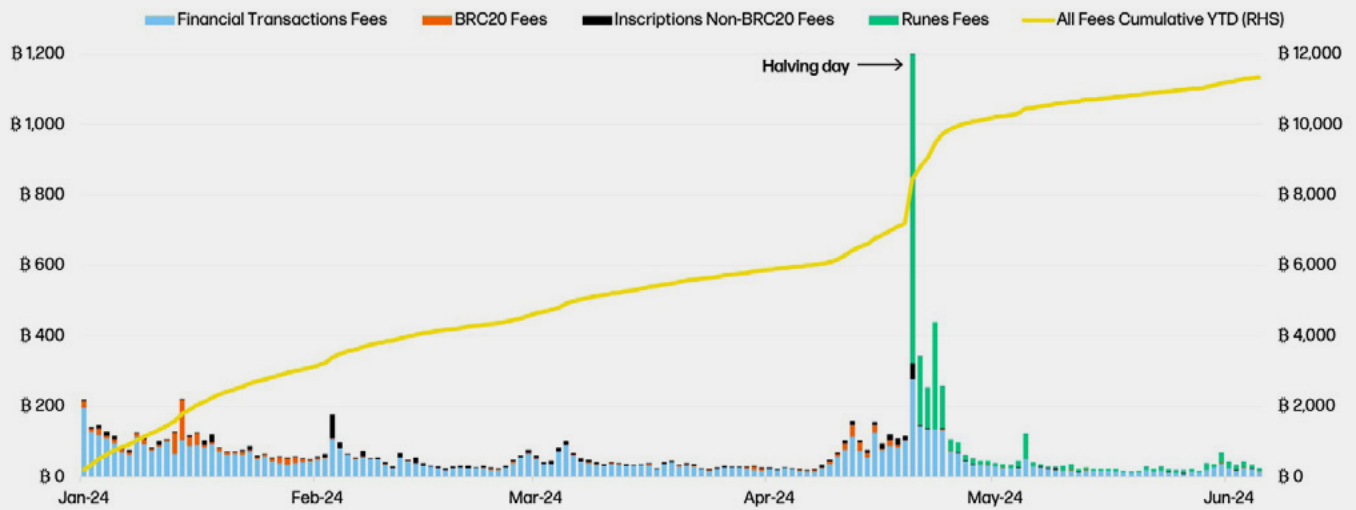
Data: Coinmetrics

Bitcoin Transactions By Type
Source: Galaxy Research

Data: Flipside, Galaxy Research

Daily Bitcoin Fees By Tx Type
Source: Galaxy Research

Data: Flipside, Galaxy Research

From January 1, 2024 through July 23, 2024, Bitcoin miners generated 12.97k BTC ($863 million as of July 23, 2024) in transaction fees. Miners have earned roughly 55% of the total fees accrued in 2023 (23.4k BTC). Bitcoin's fourth halving, which took place on April 19, 2024, has made 2024 a landmark year. On the halving day, daily fees paid to miners surged to an all-time high of over 1,200 BTC. This spike was largely due to the launch of Runes, a new UTXO-based fungible token protocol, which debuted on the halving block. On this block, Rune token XXXXXFHUXXXXX paid

$23m in fees to become the first Rune collection included in the halving block (block 840,000). Remarkably, 2,411 BTC, or 19% of the fees generated YTD, came from the halving day and three days that followed.

Since January 1, 2024, 67% of miner revenue from fees came from standard financial transactions while 19% came from Runes. BRC-20 and Ordinals transactions combined accounted for 14% of Bitcoin fees YTD.

Bitcoin Fees By Tx Type – YTD
Source: Galaxy Research
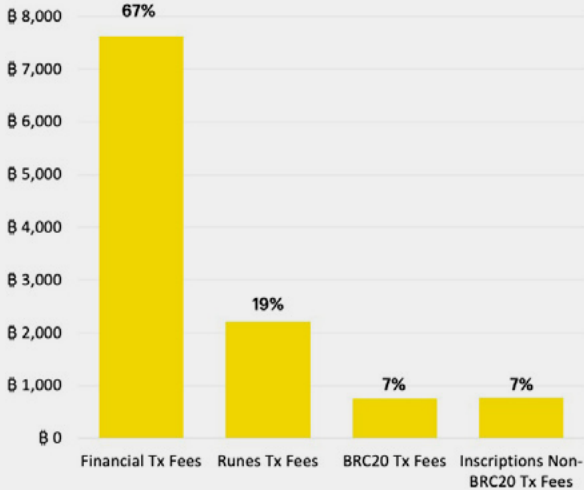
Data: Flipside, Galaxy Research

"Overpayment" is defined as the amount of fees (in sats/vByte) from transactions in a block above the median sats/vByte of the same block. We chose the median sats/vByte level of a block because we believe bidding around this level will offer a reasonable chance to be included in the next block if you are a high time preference user. Transactions that deliberately set higher sat/vByte rates are typically time sensitive. During Bitcoin's fourth halving on April 20, 2024 (UTC), transaction fees spiked significantly. The daily median fee rate reached 590 sats/vByte, while within the hour following the halving block, the average median block fee rate surged to 1,840 sats/vByte. Rune related transactions paid upwards of 250 sats/vByte higher than the median sats/vByte levels (+42% higher than the median sats/vByte) that day to be included in the halving block and a few blocks after. During the same period, standard financial transactions paid 200 sats/vByte higher than the median sat/vByte levels (+34% higher than the median sats/vByte). Since the halving, standard financial transactions overpaid more on fees than Rune transactions for 51 days total while Rune transactions overpaid more than standard financial transactions for 18 days.

Rune Tx & Financial Tx Fee Overpayment
Source: Galaxy Research
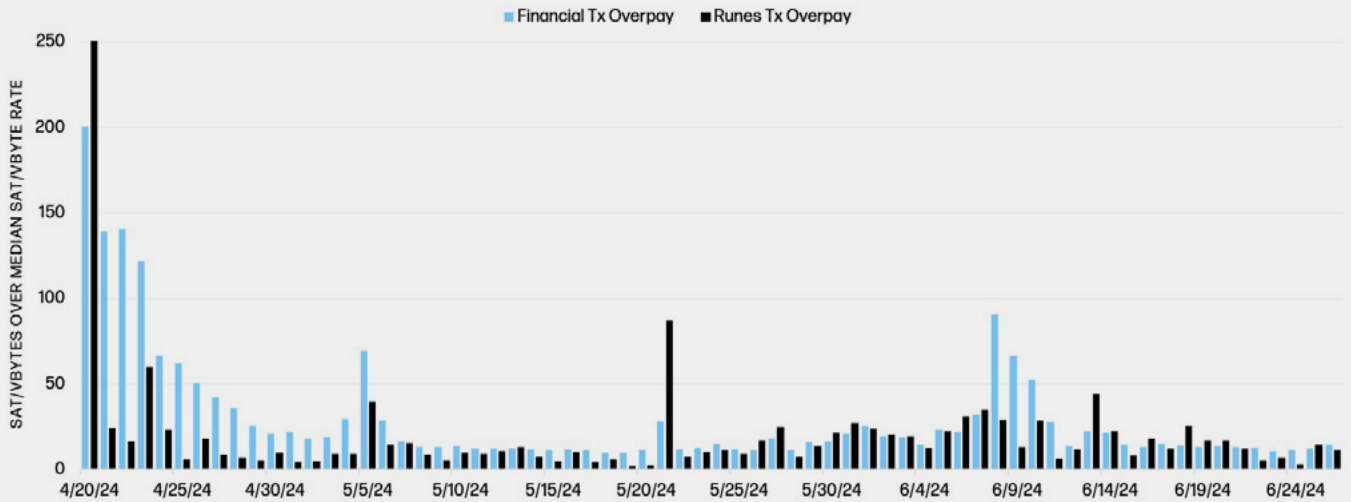
Data: Flipside, Galaxy Research

After overlaying the daily count of Rune transactions to the chart above, we found that spikes in Rune transactions are positively correlated to spikes in financial transaction overpayment. The time sensitive financial transactions are forced to compete for block inclusion with Rune transactions. While there are some days where Rune transactions overpaid more for block inclusion when Rune transactions spiked, these are considered outliers related to specific Rune token mints.

Rune Tx & Financial Tx Fee Overpayment
Source: Galaxy Research
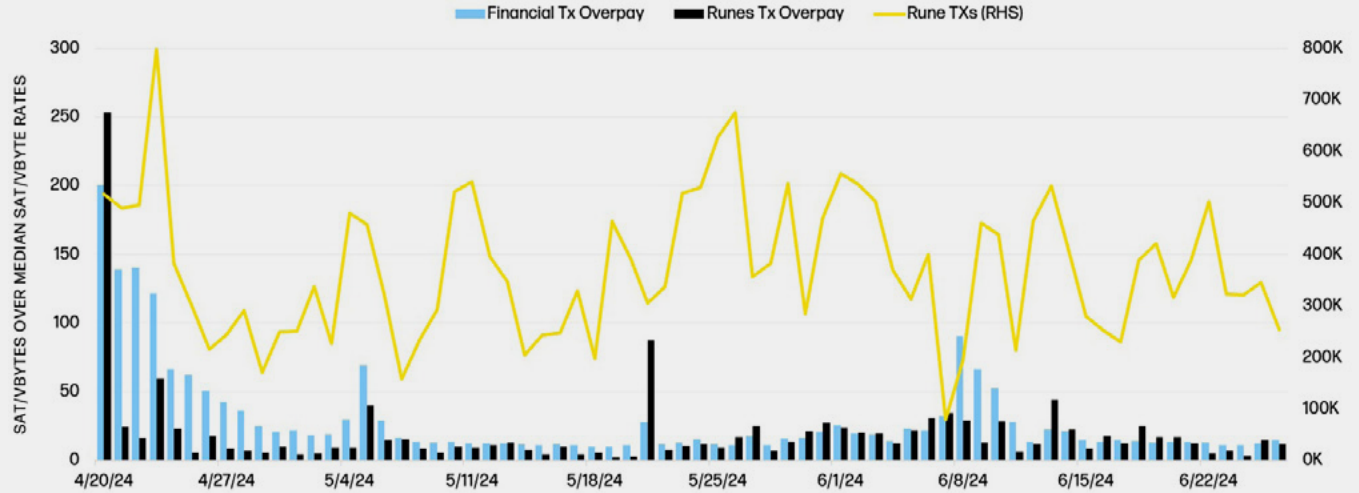
Data: Flipside, Galaxy Research

Analyzing block-by-block data reveals the frequency of standard financial transactions versus Runes transactions within 10-minute intervals. Since the halving block (block 840,000), financial transactions have averaged 2.4 MB per block, while Runes transactions have consistently occupied about 1.5 MB of blockspace. Although Runes are a more efficient fungible token standard than BRC-20s, which average 0.06 MB per block, the dominance of Runes over BRC-20s in blockspace highlights the market's preference for the Rune token standard. On the halving block, Runes transactions consumed 2.7 MB, accounting for approximately 68% of the total space in block 840,000.

Bitcoin Blockspace Composition by Tx Type
Source: Galaxy Research
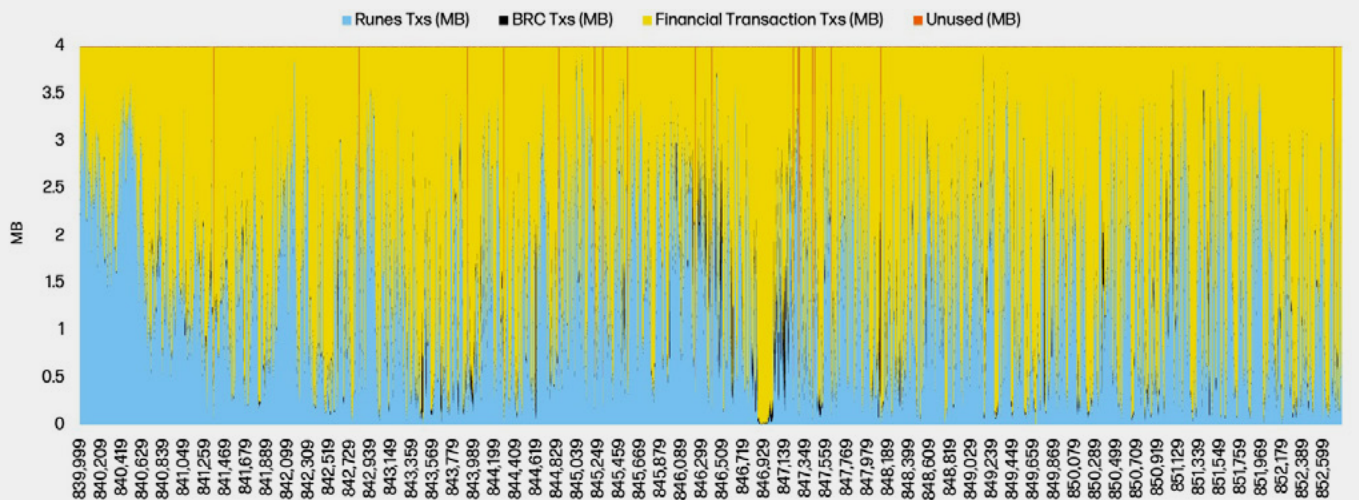
Data: Flipside, Galaxy Research

Growth/Infrastructure

An Evolving Capital Markets Landscape

Miners raised unprecedent amounts of capital in the first half of 2024. Since valuations began to surge in Q4 2023, driven by the anticipation of the Spot Bitcoin ETF approval, miners continued to raise capital – primarily equity capital - to scale rapidly up to the halving. In Q1 2024, the public miner peer set raised a combined $1.8 billion in equity capital, marking the highest amount raised in a quarter in the past 3 years.

Leading up to the halving, miners pushed aggressively to raise capital to fund rapid growth, hold bitcoin, improve fleet efficiency, and build cash buffers to capitalize on distressed opportunities. Of the $1.8 billion raised, 75% was accounted for by the top 3 miners by market cap: Marathon, CleanSpark, and Riot. The introduction of new generation machines by Bitmain and MicroBT at attractive prices provided a further sense of urgency to build out capacity and plug in machines as fast as possible to generate strong Return on Investments ("ROIs").

As depicted in the chart below, debt capital has mostly disappeared from the market since mid-2022. Previously, debt financing options available to miners were primarily structured around collateralizing ASICs. The challenge with ASIC-backed financing was the volatility of ASIC pricing, rapid depreciation of the collateral, and the absence of margin calls in many contracts. When mining conditions deteriorated, not only were the machines generating less cash flow, but their value also went down, putting lenders in precarious situations as LTVs rose and miners became unable to repay outstanding debt.

However, we expect to see lenders reenter the market in H2 2024 and into 2025 as the value of available power capacity skyrockets. The insatiable demand for power capacity from bitcoin miners and hyperscalers (i.e. large-scale data centers with scalable cloud infrastructure) has driven up the value of available energy capacity. From a lender's perspective, underwriting debt for a miner that has secured large scale power capacity in attractive locations could provide reassurance in case mining economics deteriorate. In addition, over the course of 2022 and 2023, miners focused on strengthening balance sheets by reducing debt outstanding and creating leaner cost structures. As a result, we believe the industry is in a much better position now to take on some debt and not rely solely on equity issuance for growth.

Power assets are still in a period of price discovery. Recent asset sales have occurred across a wide range in prices per megawatt, but generally have trended upwards. From a miner's perspective, leveraging the rising value of their sites can be attractive at the project level as a non-dilutive alternative and differentiator versus peers that continue to dilute shareholders as their primary source of capital. Focusing on generating free cash flow and creating lean structures, while potentially aligning debt with cash flow sweeps, can allow miners to grow in a capital efficient manner. Expanding into AI and HPC can also open doors to new sources of debt capital that pure-play miners cannot access.

Even with debt opportunities becoming more available, the "arms race" for expansion continues, and we expect significant equity capital-raising activity to persist into H2 2024. Public miners' valuations have risen on the back of ambitious growth targets, prospects of a higher future bitcoin price, and AI/HPC narratives. These increased valuations

Bitcoin Miner Source of Funds

Source: Galaxy Research

Legend: ■ Equity ■ Debt ■ BTC Sales
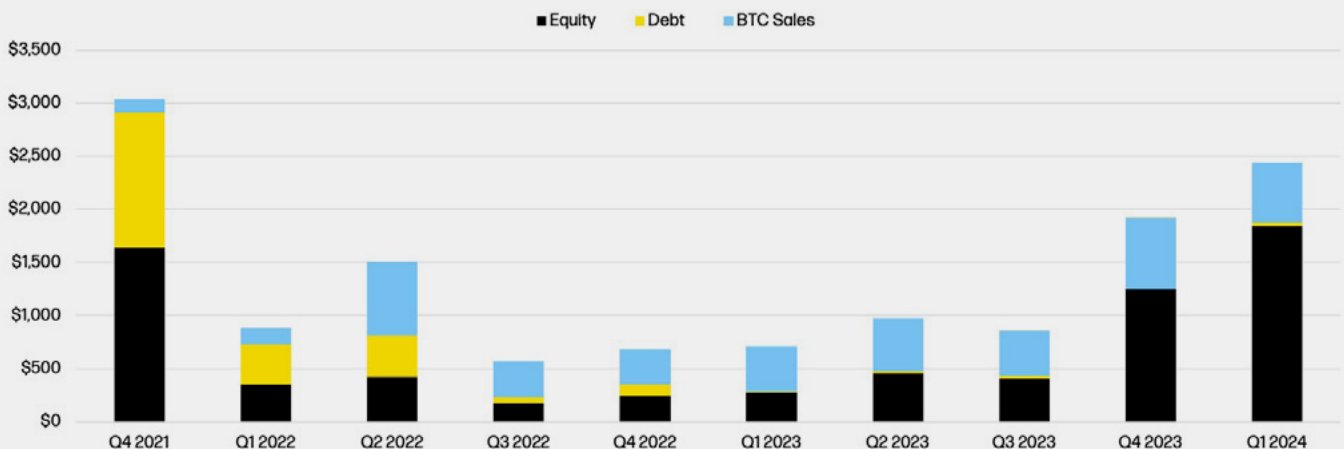
Data: Includes data from Company filings of Argo, Bitfarms, Cipher, Core Scientific, Greenidge, Sphere3D, HIVE, Hut8, Marathon, Riot, Terawulf, CleanSpark, Stronghold, and Iris Energy

help miners reduce the amount of shareholder dilution from equity issuance. With ambitious targets announced by the large public miners, it doesn't appear that there will be any slowdown in expansion and capital raising activity even as hashprice remains near historic lows.

The Multimillion-Dollar MW

Miners are at the apex of converging growth trends in Bitcoin and AI/HPC. Miners are still marginally profitable and remain in a strong position to benefit from a sustained bull run in bitcoin price given the non-linear correlation of operating costs to BTC price. Simultaneously, generative AI has one of the fastest growing adoption curves of any technology in history. ChatGPT, for example, achieved 100 million users in the first 2 months after its launch, making it the fastest growing application in history. Coupled with the fact that AI model training and inference requires an order of magnitude more electricity than traditional data center uses (an individual query of ChatGPT requires 10x the power consumption of a Google search), the AI arms race has garnered astonishing demand for access to reliable power on an expedited timeline.

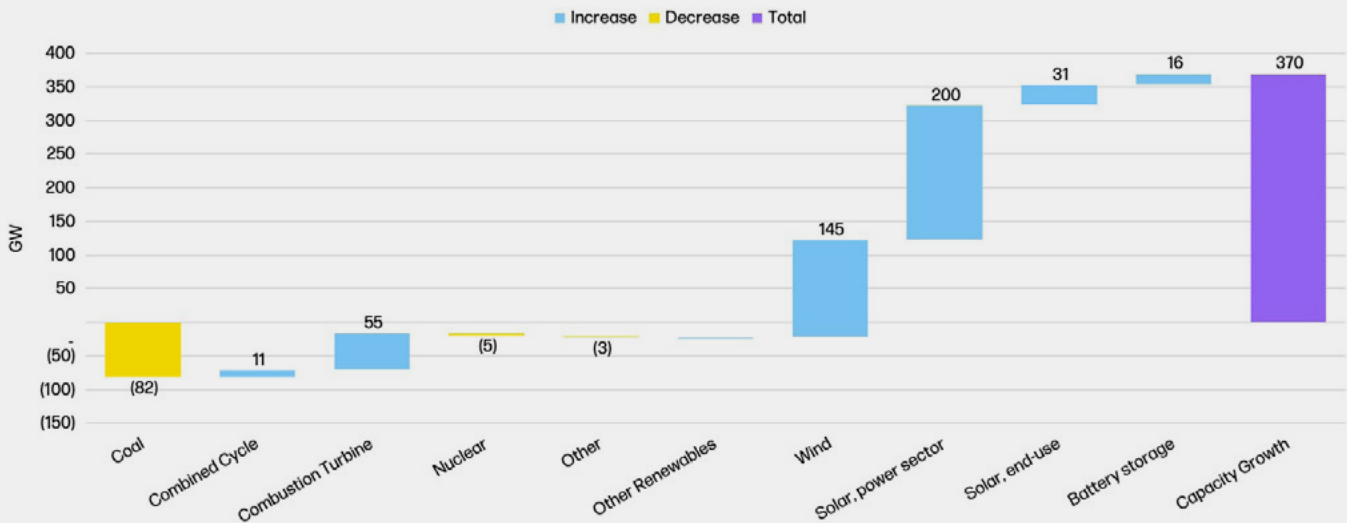Data center demand is expected to increase by 160% worldwide by 2030. Within the US, data centers are currently estimated at 21 gigawatt ("GW") of demand, which is projected to increase to 35 GW by 2030. U.S. installed generation capacity is expected to increase by ~370 GW during the same period. However, as the chart below shows, the Energy Information Administration ("EIA") is expecting dispatchable generation sources (coal, natural gas, nuclear, etc.) to see a net *decrease*, meaning that non-dispatchable, intermittent generation sources (wind, solar, etc.) would largely fill the expected gap between supply and demand. Therefore,

when you translate this into terawatt-hours ("TWh"), generation is expected to increase by 240 TWh while new data center load (assuming 99.995% uptime) would increase by 123 TWh (14 GW / 1000 * 8,760 hours/year * 99.995%). The increase in intermittent generation sources coinciding with rising demand from inflexible data center loads could lead to grid congestion, transmission constraints, and supply shortfalls given the forecasted load growth from other industries like electric vehicles and domestic industrial manufacturing. This could lead to further delays on load interconnection studies, approved ramp schedules, and facilities agreements as grid operators evaluate rapidly growing power demand relative to generation growth in the United States. In a recent interview on Dwarkesh Podcast, Mark Zuckerberg noted that no gigawatt data centers exist and that "the key now is securing energy", which is the largest bottleneck in the race to energize AI supercomputers. There is an arms race for power capacity and bitcoin miners that have access to power at scale, contiguous acreage, water, and fiber connectivity are best positioned to capitalize on this mega-trend.

While Bitcoin Mining and AI data centers have numerous differences, miners are best positioned from a time-to-market perspective to make inroads into the AI/HPC data center market. Most of the core electrical infrastructure, from the high-voltage substation components and downstream medium and low-voltage distribution systems, is similar to that which is used in traditional data centers. Some of the electrical components, including main power transformers and gas circuit breakers, have exceptionally long lead-times, and miners that have procured these assets have a competitive advantage over new entrants who face 3-4 year procurement timelines.

U.S. Installed Generation Capacity Growth Between 2024-2030
Source: Galaxy Research

galaxy

Legend: ■ Increase ■ Decrease ■ Total

	GW
Coal	(82)
Combined Cycle	11
Combustion Turbine	55
Nuclear	(5)
Other	(3)
Other Renewables	
Wind	145
Solar, power sector	200
Solar, end-use	31
Battery storage	16
Capacity Growth	370

Data: Energy Information Administration (EIA)

Miners have the land and electrical infrastructure needed to build the next generation of the world's largest data centers. Data center developers and hyperscalers will likely start bidding on these campuses in order to secure access to power at scale on an expedited basis. This trend is just beginning, with CoreWeave's $1bn offer to buy Core Scientific as a clear early mover. As traditional data center markets and co-location providers become increasingly saturated, hyperscalers will be forced to push the boundaries and move further into the secondary and tertiary markets for brownfield and greenfield developments.

Miners started venturing into AI/HPC in 2023, but the CoreWeave and Core Scientific 200 MW hosting deal in June 2024 took the industry by surprise. Prior to the AI boom, these "megasites" owned by large miners were valued purely for their bitcoin mining potential. However, the impact of the CoreWeave deal on Core Scientific's stock price is evidence that miners can benefit from the AI upside. The graph below shows that miners who have taken steps towards adopting a hybrid mining/AI approach have benefited compared to those that have remained focused on a pure-play mining strategy.

This upside exists because, as of now, economics for AI/HPC contracts are strong. When you boil it down into dollars per megawatt-hours ("$/MWh") figures, the newest generation machines for bitcoin mining produce ~$125/MWh (S21 Pro at hashprice of $0.053/TH/DAY) that fluctuates with movements in hashprice. Assuming $40/MWh cost of electricity, the gross profit per MWh is $85/MWh. In comparison, as part of the Core Scientific/CoreWeave deal, CoreWeave is willing to pay a fixed $118/MWh in addition to pass through electricity costs on 280 MW (Graphic Processing Units ("GPUs") + IT and mechanical cooling infrastructure) for Core Scientific to provide managed services, even after paying for a majority of the capex investment.

If the market continues to reward miners that pursue AI/HPC opportunities, we believe there will be fewer pure-play bitcoin miners with megasites in the future, especially if hashprice stays low.

As of July 22nd, the combined market cap of the companies in the previous chart (Pure-Play + Hybrids) was $28.2 billion. When you compare this figure to the capital pouring into AI, as shown in the chart below, it is hard to imagine a future in which well-positioned miners won't pivot to a hybrid approach. Hyperscalers, including Amazon, Microsoft (Stargate, Wisconsin, Sweden), Google, and others, have announced massive growth plans in AI over the next several years as the demand for compute grows.

Some bitcoin miners have already benefited from some of the AI upside. However, until miners prove that they can build and operate these data centers at scale, they will continue to trade at a discount to the pure-play data center providers.

Pure-Play Miner vs Mining-HPC Hybrid Company Market Cap Comparison
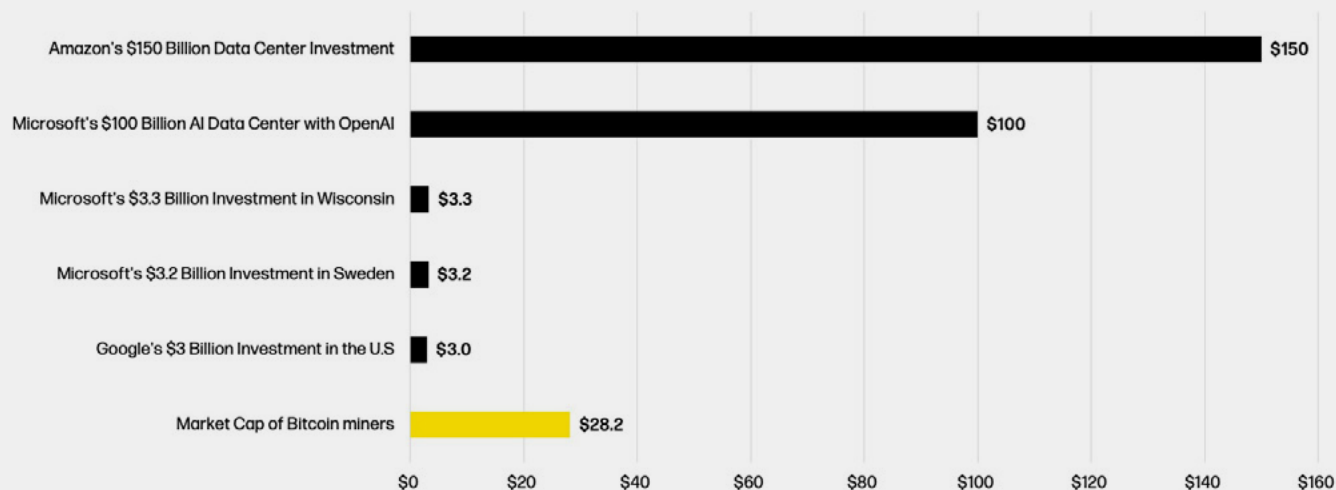Source: Galaxy Research
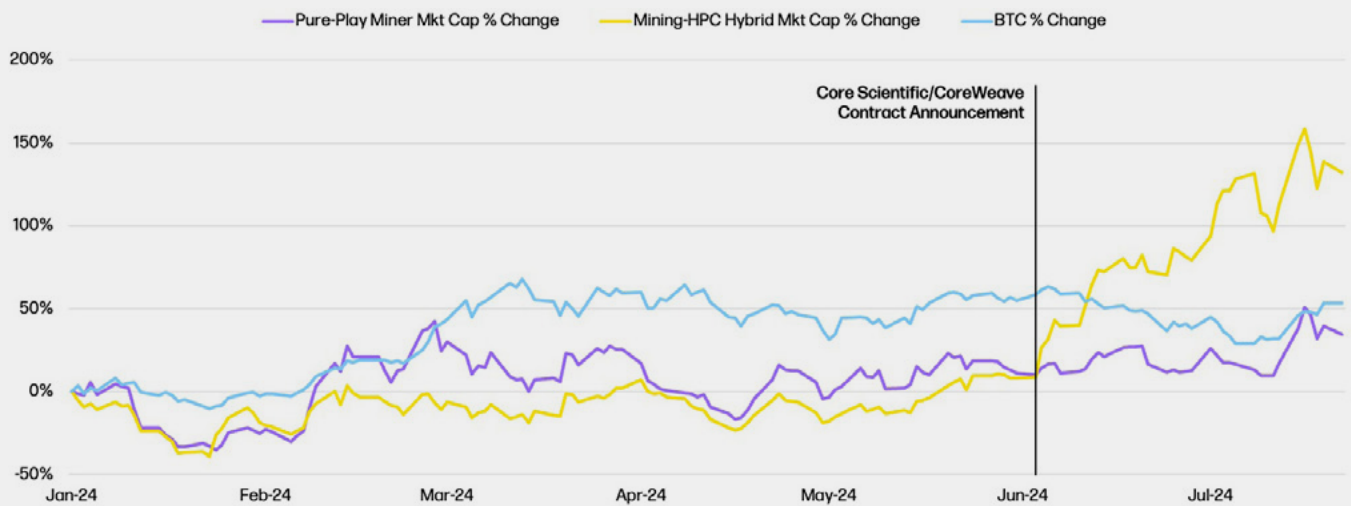
Data: Bloomberg; Pure-Play Miners include MARA, RIOT, CLSK, CIFR, and BITF. Mining-HPC Hybrids include HUT, WULF, HIVE, BTBT, IREN, CORZ, BTDR, and APLD

Announced Capital Investment in AI ($bn)
Source: Galaxy Research

M&A Synopsis

Throughout 2024, Bitcoin miners have engaged in a significant number of M&A transactions. As predicted in our previous report, the trend towards M&A has been consistent. Miners are increasingly becoming vertically integrated by acquiring sites to enhance input control. To date, over $460 million has been transacted across various deals, primarily categorized into site sales, reverse mergers, and company acquisitions. Record low hashprice and a steepening ASIC efficiency curve compelled miners to adopt more strategic approaches to achieve greater operational excellence. Some of the motivations for the widespread M&A observed in 2024 include:

- **Vertical Integration:** The era of being 'asset-light' is fading. Previously, miners would host their entire fleet at a fixed power price, sacrificing the flexibility to optimize operations for cost efficiency. With post halving hashprice hitting record lows, this forces miners to more than ever attain vertical integration, enabling them to manage dismal hashprice conditions and declining mining economics either through economic curtailment or by reducing operational overhead. Over 1.1 GW of power access has changed hands throughout 2024, showing a move in miners gaining more control of their operations. Public miners are investing approximately $404,000 per MW for power access, encompassing both immediate and future needs.

- **Business Consolidation:** The public mining sector has seen notable types of transactions, highlighting reverse mergers as many mining operations were previously sustained by legacy fixed rate agreements, which are no longer economically viable, prompting widespread consolidation.

- **Diversification:** 2024 has been a year of seeking synergies through diversification, be it geographical expansion into emerging markets with lower energy costs or diversifying revenue streams beyond mining. For instance, Bitdeer's acquisition of ASIC designer Desiweminer illustrates this strategy by acquiring in house expertise to propel the launch of their own proprietary ASIC, allowing them to capture another revenue stream outside of bitcoin mining.

Future M&A Opportunities

For those who have not upgraded fleet efficiency post halving or been able to adjust their costs, we may see erosion of liquidity, depleting their capital reserves, as they seek exits or wait for an acquirer to take advantage of their distressed situation. If hashprice remains below $0.06/TH for an extended period, we might see an increase in distressed offerings, like the situation in late 2022. At this hashprice level, there is little room for margin beyond power price, not to mention when factoring in associated operating expenses, depreciation and any outstanding interest. For example, at current hashprice levels some of the most popular previous generation machines, notably the Antminer S19j Pro, yield a $/MWh revenue of approximately ~$70/MWh. Taking a blanket average power price of $60/MWh leaves little room to bake in all other associated costs when addressing a miner's bottom line.

Despite the precarious financial situations of some miners, those that own power assets may become attractive acquisition targets. The demand for power continues to grow within the high-performance computing sector. Hyperscalers, for example, face a shortage of power capacity relative to their service demand needs and are willing to pay substantial premiums for it. Earlier this year, Amazon Web Services purchased capacity for $677,000 per MW, significantly higher than the average mining transaction cost per

MW in 2024. Asset-heavy miners serve as a proxy for power access, as grid interconnection timelines within the U.S. remain stretched and demand for AI remains strong. It will be notable to see the amount hyperscalers are prepared to bid for power connectivity.

For smaller private miners, access to affordable capital remains a challenge. Even with debt markets reopening, the debt service coverage ratio may still be inadequate. These miners might consider a reverse merger with a publicly listed entity to leverage at-the-market offerings.

Evaluating Attractive Prospects

The ever-changing dynamics of what impacts the market value of a company gives choice when narrowing the focus of why a target is attractive. This choice arises primarily from changes in power markets, premiums given to public companies that are dependent on their strategy, and access to capital. Evaluating the ideal target sometimes may seem like a game of cat and mouse, trying to comprehend what the market values and foreseeing waves of demand. The following lay out certain features of why a target may be appealing:

- **Readily Available Capacity:** Miners who not only have existing power capacity, but a healthy pipeline of approved power with a clear path to energization can be attractive targets; "verbal commitments" will not cut it. Same can be said for smaller miners who were not able to hit scale, could not upgrade their fleets, or run a barely profitable operation, yet sit on valuable power assets that could achieve better margins by deploying more efficient machines or shifting to AI/HPC.

- **Contracted Predictable Revenues:** Letters of Intent ("LOIs") and term sheets don't boast stability. Miners who have contracted revenue over a certain period allow for consistent cash in the door. Given the speculative nature of mining economics, where miners inherently are exposed to hashprice volatility, it is prudent to diversify revenue streams.

- **Previous Generation Fleets:** When considering ASIC price speculation, there are many miners with less efficient fleets that can sell their ASICs at a discount relative to some of their peers with more efficient fleets. This can make the $/TH price attractive, offering a good price entry point in terms of ROI on these secondary machines. Some of the previous generations (30 j/TH) are selling for an attractive price whether you want to mine (at low power cost) or speculate on resell. Although this may not be accretive in the context of achieving high multiples, it allows for a quick return while maintaining optionality for fleet upgrades in the future.

In essence, some miners can be valuable targets for compute-hungry companies to quickly access scalable power. Especially those miners with large interconnection agreements, a pipeline of electrical infrastructure growth, and ample space. Having this trilogy increases the $/MW premium that miners can achieve from selling such capacity. As the demand for compute-power grows, we are excited to see how this impacts the valuation of miners and their attractiveness as investment prospects.

Hashrate Forecast

In our Annual Report, we estimated a range of 675 EH to 725 EH for our end of 2024 hashrate target. **We are now revising our growth upwards to between 725 EH and 775 EH.** To derive our revised estimations, we look at a subset of public miners and their hashrate targets to understand what we know with reasonable likelihood would come online this year and extrapolate that to the rest of the network. We also analyze historical hashrate seasonality as an additional benchmark. To complete the analysis, we analyze network breakeven points to validate the range.

First, we will look at hashrate growth from public miners for H2 2024. In the first half of 2024, assisted by skyrocketing valuations and immense capital raised in equity markets, public miners entered large scale purchase orders for new generation machines. The below table summarizes June realized hashrate numbers, end of 2024 targets, and the implied hashrate growth for H2 2024 from a subset of public miners. **Collectively, and assuming each one hits their stated targets, these public miners are expected to energize 109 EH of incremental hashrate, representing ~18% network hashrate growth from just 7 miners.**

Public Miner Current and Projected Hashrate
Source: Galaxy Research

Company	Current Realized Hashrate	End of 2024 Target	Hashrate Growth
Bitfarms	7.5 EH	21.0 EH	13.5 EH
Cipher Mining	6.8 EH	13.5 EH	6.7 EH
Marathon Digital	23.5 EH	50.0 EH	26.5 EH
Riot Blockchain	10.2 EH	31.5 EH	21.3 EH
Terawulf	7.1 EH	13.3 EH	6.2 EH
CleanSpark	17.8 EH	32.0 EH	14.2 EH
Iris Energy	9.3 EH	30.0 EH	20.7 EH
Total	82.1 EH	191.3 EH	109.2 EH

Data: Company Filings and Press Releases

Public Miner % Share of Network Hashrate
Source: Galaxy Research
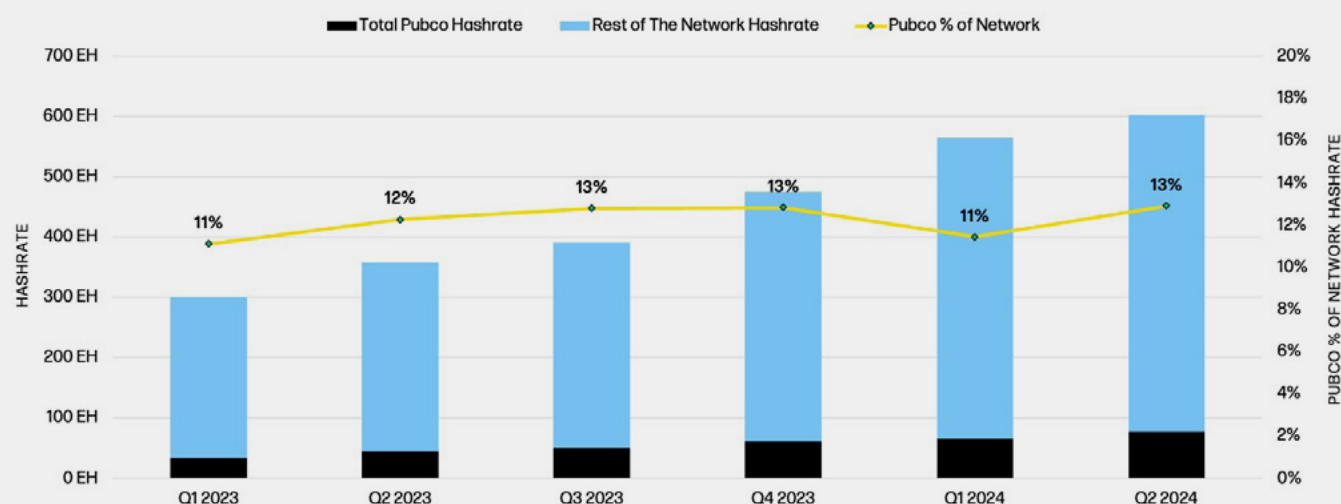
Data: Coinmetrics and Public Miner Filings and Press Releases. Public Miner data includes Bitfarms, Cipher, Marathon, Riot, Terawulf, CleanSpark, and Iris Energy

Next, to estimate growth for the remainder of the network, we analyze how hashrate of this subset of public miners has trended versus the rest of the network. As shown above, historically this subset of public miners has made up 11%-13% of the network.

An overly simplified approach would be to divide 109 EH by 13% to derive an extraordinary 838 EH of growth for the rest of the network. However, this assumes that public miners will continue to maintain a 11-13% proportion of the network. The scenario table to the right shows what end of year hashrate would be if we vary public miners' share of end of year hashrate and assume current network hashrate of 587 EH, public miner hashrate growth of 109 EH, and current public miner share of network hashrate of 13%. We estimate that public miners will grow their share of the network closer to 15%-30%, with a benchmark of 25%. This is because public miners have access to US capital markets and were able to raise significant capital in Q1 2024, an immense advantage when compared to private miners. At 25% share of end of year hashrate, this implies 741 EH of total network hashrate, meaning the rest of the network would add **45 EH** of growth in H2 2024.

Implied End of Year Network Hashrate Assuming Different Public Miner % Share of Network Hashrate
Source: Galaxy Research

Public Miner % Share of Total Network Hashrate	Implied End of Year Hashrate	Rest of Network Hashrate Growth
10.0%	1853 EH	1157 EH
12.5%	1482 EH	786 EH
15.0%	1235 EH	539 EH
17.5%	1059 EH	363 EH
20.0%	927 EH	231 EH
22.5%	824 EH	128 EH
25.0%	741 EH	45 EH
27.5%	674 EH	-22 EH
30.0%	618 EH	-78 EH

Data: Coinmetrics and Public Miner Filings and Press Releases. Public Miner data includes Bitfarms, Cipher, Marathon, Riot, Terawulf, CleanSpark, and Iris Energy

As a result, strictly from looking at public miners, this puts our benchmark for hashrate growth at 741 EH. This is a substantial amount of additional hashrate that we predict will come online in the second half of the year, which we think is feasible through machine replacements and net new capacity coming online. Revisiting an analysis that we conducted in our previous Annual Report, the below sensitivity table shows what network hashrate would reach under different combinations of percent of the network that is replaced and additional GW capacity expansion. We start with a network hashrate of 587 EH and assume that new machines that are plugged in have an efficiency of 17.5 J/TH and machines being replaced have an efficiency of 30 J/TH.

Total Network Hashrate Assuming Different Levels of Additional GW Capacity and % Replacements
Source: Galaxy Research

| | The Percent of ASICs being Replaced with Newer Generation Machines Over the Course of 2024 | | | | | | | |
	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%	35.0%	40.0%
0.50 GW	637 EH	658 EH	678 EH	699 EH	720 EH	741 EH	762 EH	783 EH
0.75 GW	651 EH	672 EH	693 EH	714 EH	735 EH	756 EH	777 EH	798 EH
1.00 GW	665 EH	686 EH	707 EH	728 EH	749 EH	770 EH	791 EH	812 EH
1.25 GW	679 EH	700 EH	721 EH	742 EH	763 EH	784 EH	805 EH	826 EH
1.50 GW	694 EH	715 EH	736 EH	757 EH	778 EH	799 EH	819 EH	840 EH
1.75 GW	708 EH	729 EH	750 EH	771 EH	792 EH	813 EH	834 EH	855 EH
2.00 GW	722 EH	743 EH	764 EH	785 EH	806 EH	827 EH	848 EH	869 EH
2.25 GW	737 EH	758 EH	778 EH	799 EH	820 EH	841 EH	862 EH	883 EH
2.50 GW	751 EH	772 EH	793 EH	814 EH	835 EH	856 EH	877 EH	898 EH
2.75 GW	765 EH	786 EH	807 EH	828 EH	849 EH	870 EH	891 EH	912 EH
3.00 GW	779 EH	800 EH	821 EH	842 EH	863 EH	884 EH	905 EH	926 EH

Row axis label: Additional Capacity Expansion in 2024

Analysis assumes new machines have specifications equivalent to the S21
Analysis assumes the average ASIC being replaced has an efficiency of 30 j/TH
Data: Galaxy Research

We assume in the above table that S21s are deployed, but as we look beyond 2024, the table highlights the impact that simply just replacing older generation machines with new generation machines can have on network hashrate. Coupled with announcements from new ASIC manufacturers that suggest bitcoin mining ASICs could achieve an efficiency of 5 J/TH next year, this would provide another meaningful boost to network hashrate in 2025.

The next portion of our analysis observes historical hashrate trends through summer months and into the end of the year. As shown in the chart below, hashrate has typically stabilized during summer months from July – September. This is likely driven by a growing percentage of the network residing in Texas and the Middle East, where miners have to underclock because of high temperatures. In addition, Texas miners curtail because of volatile pricing, Four Coincident Peaks ("4CP") avoidance, and participation in demand response programs.

After summer months, network hashrate has taken off as uptimes increase, underclocking needs lessen, and miners plug in new machines. Public miners are expected to ramp up hashrate significantly in the second half of the year, and we expect a similar dynamic to play out this year, where summer months have marginal growth in network hashrate, followed by a rapid acceleration going into the end of the year.

Network difficulty in 2024 has followed a similar growth trajectory to that of 2022 and 2023. In 2024 difficulty has moved in lockstep with 2022's difficulty trends. In 2022, from October to the end of the year, difficulty increased by 14% from September to the end of the year. In 2023, difficulty increased by 29% from September to the end of the year. If we apply these growth rates to a 587 EH current network hashrate, that implies a range of **670 EH to 760 EH**. While our previously derived target from public miners is at the higher end of this range, it gives us confidence on what is feasible from an infrastructure buildout standpoint.

The final analysis is to understand what implied hashprices are based on our target hashrate to understand what is economically sustainable by the network. There are several variables that impact this sensitivity analysis including bitcoin price, transaction fees, average network power prices and network efficiency levels. Given the volatility of transaction fees, we will assume they stay fixed at 10% of block subsidy (0.3125 BTC) per block.

For average network power prices, we analyzed recent downward moves in hashrate to understand where the marginal unit of power prices lie. Post halving, the network witnessed a downward adjustment of 5.62%, bringing hashprice to $0.052. Using Coinmetrics' MINE-WATCH, the average estimated network efficiency was 33.3 J/TH, which implies an average network power price of $65/MWh.

Network Difficulty Growth Over the Past 3 Years
Source: Galaxy Research
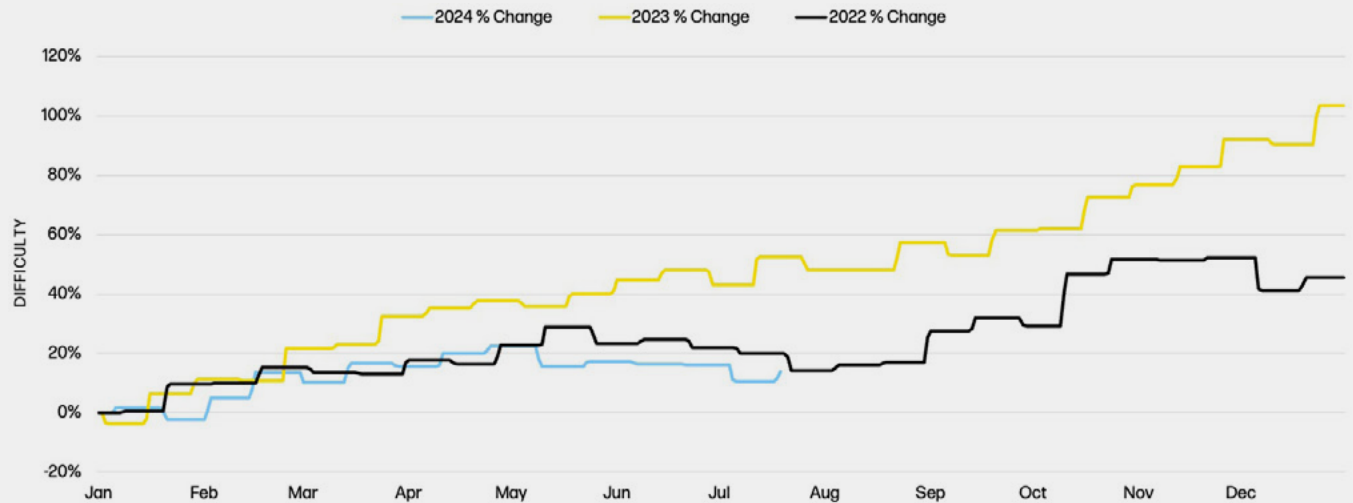
Data: Coinmetrics

Gross Profit Margins for Different Combinations of Network Hashrate and Bitcoin Price
Source: Galaxy Research

	Network Hashrate						
	650 EH	675 EH	700 EH	725 EH	750 EH	775 EH	800 EH
$45,000	-20.4%	-25.1%	-29.7%	-34.3%	-39.0%	-43.6%	-48.2%
$45,000	-20.4%	-25.1%	-29.7%	-34.3%	-39.0%	-43.6%	-48.2%
$50,000	-8.4%	-12.6%	-16.7%	-20.9%	-25.1%	-29.2%	-33.4%
$55,000	1.5%	-2.3%	-6.1%	-9.9%	-13.7%	-17.5%	-21.3%
$60,000	9.7%	6.2%	2.7%	-0.7%	-4.2%	-7.7%	-11.2%
$65,000	16.6%	13.4%	10.2%	7.0%	3.8%	0.6%	-2.6%
$70,000	22.6%	19.6%	16.6%	13.6%	10.7%	7.7%	4.7%
$75,000	27.7%	25.0%	22.2%	19.4%	16.6%	13.8%	11.1%
$80,000	32.3%	29.7%	27.0%	24.4%	21.8%	19.2%	16.6%

(Row label: Bitcoin Price)

Data: Galaxy Research

As network hashrate grows, the machine mix will become increasingly more efficient. As a result, we assume a 20% improvement in network efficiency (lower J/TH), this brings efficiency to 26.6 J/TH. At these efficiency levels and holding power prices constant at $65/MWh, the breakeven hashcost for the network would stand at $0.041/TH. While hashprice quantifies the revenue per terahash of computing power, hashcost shows the total energy cost per terahash. If we sensitize bitcoin price and network hashrate and assume transaction fees are fixed at 10% of block subsidy, the above chart shows the average gross margins for the network. **Assuming bitcoin price stays within a $65,000-$70,000 range, the network can still support a hashrate of 741 EH, providing further confirmation that these levels are economically sustainable.**

In conclusion, using the information we have available from public miners on growth targets, seasonality comparisons with previous years, and an analysis of economics, **our preliminary hashrate target is 741 EH. We've created a range of 725 EH to 775 EH around this number because of the uncertainty surrounding machine deployments**. There are a number of factors that we recognize that could cause deviations from this range. On the upside, improvement in mining economics and faster than expected releases and deployments of machines are a couple that could take us above 775 EH. On the downside, further deterioration in hashprice or significant diversion of capital from bitcoin mining to AI/HPC could slow growth.

Conclusion

The first half of 2024 has been a defining period for the Bitcoin mining industry, marked by significant economic challenges and groundbreaking developments. Despite reaching all-time lows in mining economics, the sector has demonstrated remarkable resilience and adaptability in the face of all-time low hashprice and high demand for power.

The convergence of AI/HPC with Bitcoin mining signifies a transformative new endeavor for many companies as they seek to capitalize on the strong, uncorrelated economics of this industry.

Access to power is a clear bottleneck now, as demand from AI/HPC data centers and miners continues to grow. As a result, miners with access to large amounts of power are in strong positions to differentiate themselves, and it will be crucial for these miners to remain nimble going into the future and allocate MW capacity in the direction that maximizes shareholder returns.

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