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BitOoda

2022 Year End Bitcoin Hashpower Estimate:

Nudging Down to 327 EH/s on Power, Semi Delivery Schedules

Research

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A key factor determining investment returns from Bitcoin mining is an estimate of future Hashrate and difficulty. Whether directly investing in mining assets or in mining stocks, this estimate is critical. The mining investment's share of future Hashrate determines future Bitcoin earnings.

We assess Hashrate could reach 327EH/s by year end 2021, versus our prior 334 EH/s estimate. The year end 2021 Hashrate came in at 174EH/s, below our previous estimate of 198EH/s. The situation in Kazakhstan further pressures near term Hashrate. The longer lead time site development schedules in North America remain intact.

Long-term Hashrate is price dependent: profitability is a key determinant of miner balance sheet health and confidence, as well as investor funding. But in the nearer term, other constraints also apply.

We identify four constraints on Hashrate for 2022 (slide 6): availability of capital, mining rigs, cheap power at 240V single phase, and a supportive price environment that keeps rigs operational. We developed reasonable forecasts of each of these constraints to arrive at our Hashrate estimate, which we pegged at the lowest of the four constrained values.

We believe growth of ~208 EH/s can be funded through a combination of internal generation and external capital, although the percentage of capex fully funded already is unclear. This is in addition to replacement capex for existing capacity, which includes about 88 EH/s of announced growth by just 18 public miners who currently account for 14% of the network **(slide 9). This would take 2022YE network Hashrate to 382 EH/s (slides 8-13).**

We believe the semiconductor foundries could support about 112,000 wafer starts for mining ASICs in 2022 (slides 15-25). This is consistent with deliveries achieved in the past year, and would take the network to **327 EH/s**, including factoring in obsolescence and failure of older rigs in the existing fleet. **We find this is the operative minimum value, and thus our official 2022 YE estimate.**

After adding just 24MW of net effective power capacity in 2021, we believe as much as 4-5GW of capacity addition is possible in 2022 (slides 28-33). The low net addition last year was a result of several GW going offline in China in the late spring, and speaks to the underlying ability of the market to deliver enough power at the right price and voltage. This would lead to **334EH/s** by year end, coincidentally our prior, power-constrained estimate. While we see environmental and political backlash against the power intensity of Bitcoin, we firmly believe that Bitcoin has a positive role to play in accelerating the transition of the grid to renewable energy while reducing the need for taxpayer-funded subsidies. **We plan to address this issue in detail with an upcoming research report.**

Mining profitability has been mean reverting in the past month. The recent Bitcoin selloff is moving in the opposite direction to Hashrate, eroding miner margins. We examine BTC price / network Hashrate combinations at which the estimated 8.4 EH/s of remaining S9 machines would shut down ($35k at YE 327 EH/s), and the 45 EH/s of S17 class machines would shut down (under $20k at 327 EH/s). S19 class machines, though, can sustain profitability at $20k Bitcoin even at **400 EH/s** network Hashrate (slides 35-46).

Transaction (Tx) fees have remained lower than previously anticipated. We suspect a shift of trading from Asia to the West, coupled with a reduction in overall trading volumes, may be a factor, reducing on-chain transactions. Over time, increased Layer 2 deployment would also lower Layer 1 congestion and thus fees. We are lowering our long-term Tx fee estimates in our profitability analysis and plan a deeper dive into the issue in the coming weeks.

Our analysis suggests Hashrate growth in 2022 will be back-end loaded: 12.8 EH/s per month on average, but just 18EH/s in Q1 vs. 50+ EH/s in Q4 (slide 49). We also calculate theoretical Bitcoin prices needed to maintain revenue per PH/s at recent levels given our estimate of future Hashrate (slide 51).

Risks to our Hashrate estimates (slide 67): upside risk is driven by easing infrastructure and semiconductor constraints, coupled with a surging price. On the downside, environmental or political headwinds could slow permitting and deployment of capacity. A sustained bear market could substantially reduce capital flows and internal generation, leading to miner defaults or an inability to accept delivery of partially funded rigs. The Kazakh situation poses near term risk as well.

Key Takeaways

- *We expect to see a 327EH/s network Hashrate by year end, driven by semi and power constraints*

Constraint	YE 2022 Hashrate
Capital	382 Eh/s
Chip Capacity	327 EH/s
Power Availability	334 EH/s
Profitability	400 EH/s
Min = BitOoda Estimate	**327 EH/s**

- *With a Bitcoin mining cost curve median of $40/MWh, S9s shut down at a $35k price and S17s at $20k, but S19s can sustain operation under $20k even at 400EH/s network Hashrate*
- *Downside risks include political / environmental as well as miner defaults and funding gaps in a crypto bear market*

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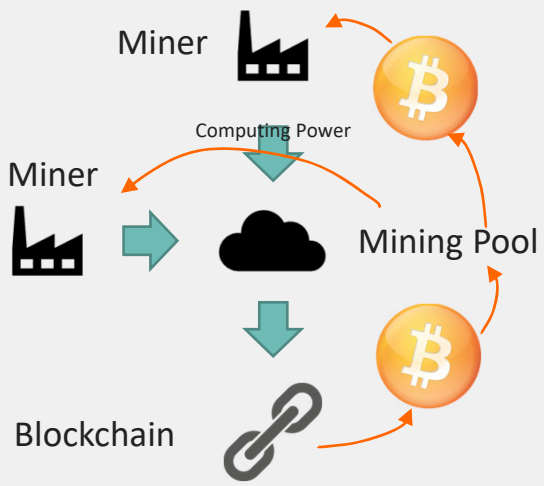
Introduction

Our approach to estimating Hashrate

Overview of Hashrate and Mining Economics



- Miners receive rewards as compensation for validating transactions in two forms: (1) each block consists of a number of transactions awaiting validation for a fee, paid by the transactor, and (2) the block includes a reward – currently 6.25BTC per block until mid-2024 – of freshly minted Bitcoin that the protocol generates as an incentive for mining
- Miners contribute their computing power into a mining "pool" to try and solve a brute force puzzle. The first pool to solve the puzzle receives the reward, and the mining pool distributes the total daily rewards (after pool fees) to the different participants in the pool, based on their share of contributed computing power. This pool system helps stabilize cash flows and ensures that even small miners get a fair share of rewards, with less of an impact of luck
- The number of blocks mined each day is targeted at roughly 144, with the complexity of the puzzle changing roughly every 14 days, rising or falling as needed to maintain the 144-block production rate
- In addition, the number of BTC rewards in each block halve every 2,100,00 blocks or ~4 years, the notion being that block rewards are a temporary incentive until time and usage grow transaction fees to the point the network becomes self sufficient
- Thus, the number of Bitcoin minted each day remains roughly the same, halving every 4 years
- **If network computing power or "Hashrate" increased over time, the share of the total daily rewards earned by one unit of mining "Hashpower" would fall**
- **This paper provides a methodology for estimating Hashrate over the lifetime of a mining investment, given that Hashrate is a critical driver of the viability of a mining project**

Revenue Considerations

- Transaction Fees influence total daily BTC mined
- Network growth drives each miner's share of BTC mined
- Revenue = Bitcoin Price x BTC Volume Mined
- Thus, we need to develop reasonable forecasts around each of these three key variables

Expense Considerations

- The biggest operating expense is power
- Labor and maintenance costs are relatively modest
- Capex is significantly influenced by rig price and availability, which are driven by Bitcoin price and semiconductor availability
- Decisions such as immersion vs. air cooled and building vs. containerized, as well as existing facility infrastructure, influence timing, investment and payback periods

Hashrate estimates are the most important revenue driver for a mining project, more than price

Current Network Stats
Most S9-class Rigs Retired

- By our estimate, the 1/3/22 target Hashrate of ~174 EH/s is comprised of ~2.6mm rigs drawing ~6.6GW of power (~58TWh annually)
- About 23% of rigs are still legacy S9-class machines, consuming 13% of power and generating ~5% of total network Hashrate
- With about 120,000 blocks to go before the next halving in 2Q 2024, and an ongoing increase in Hashrate, only about 3% of these machines will mine a block
- **These estimates are approximate and intended just to scope the network size**

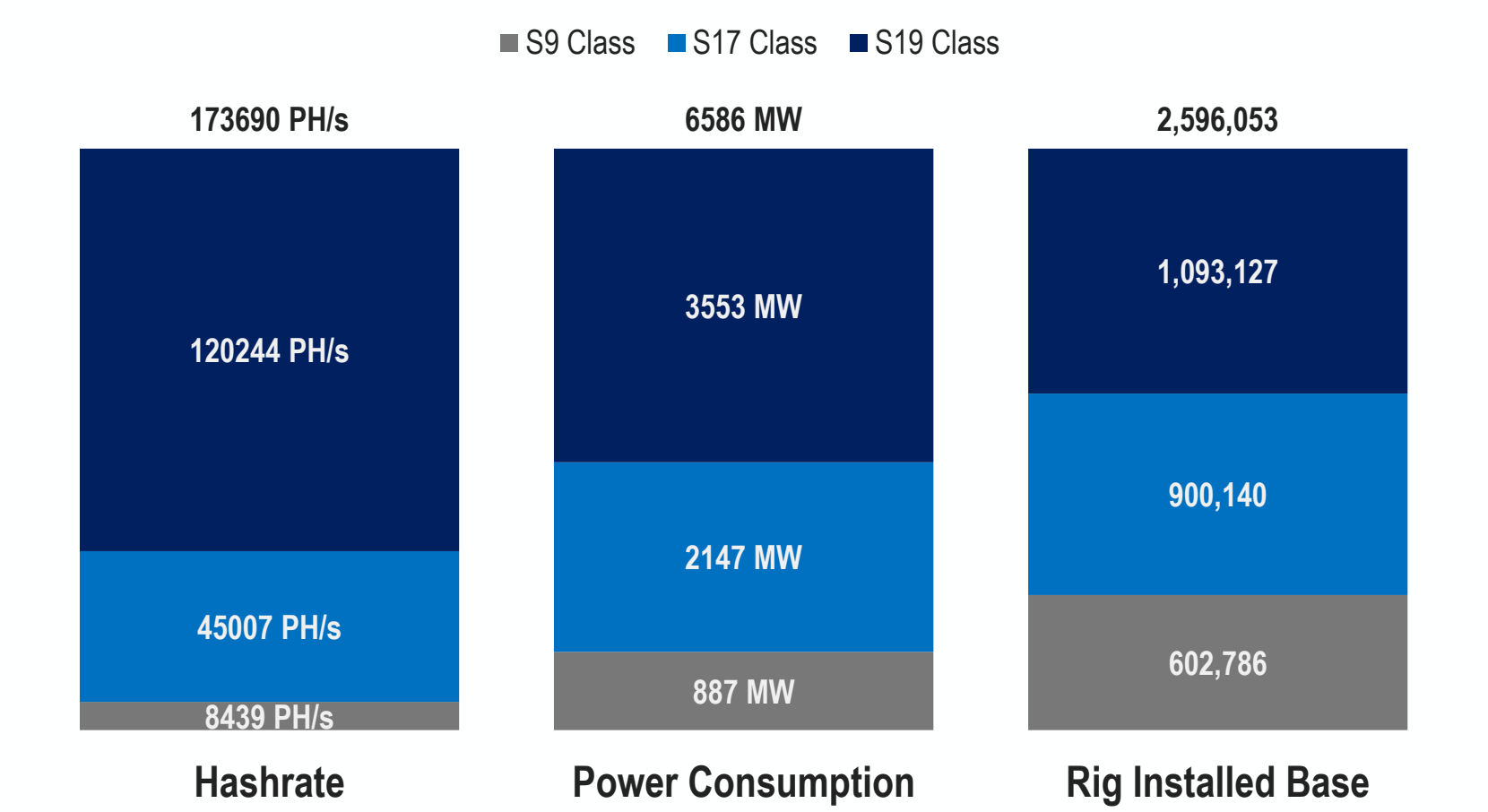


Figure: Bitcoin mining network estimates as of 1/3/2022: Hashrate, power and rig installed base by rig generation

Source: BitOoda estimates, CoinMetrics, Bloomberg

Hashrate Limits

How large can the network get?

- The global semi chip shortage is well known, if less well understood
- With the shutdown of mining in China and emerging regulatory pushback in Kazakhstan, access to cheap power – at the right voltage, with the right power infrastructure, in a benign regulatory and community structure – is critical
- We assess the contours of capital and profit limits on mining
- **Timing differences aside, network Hashrate will converge to the lowest of these constraints (although overshoots are possible, or perhaps even likely)**

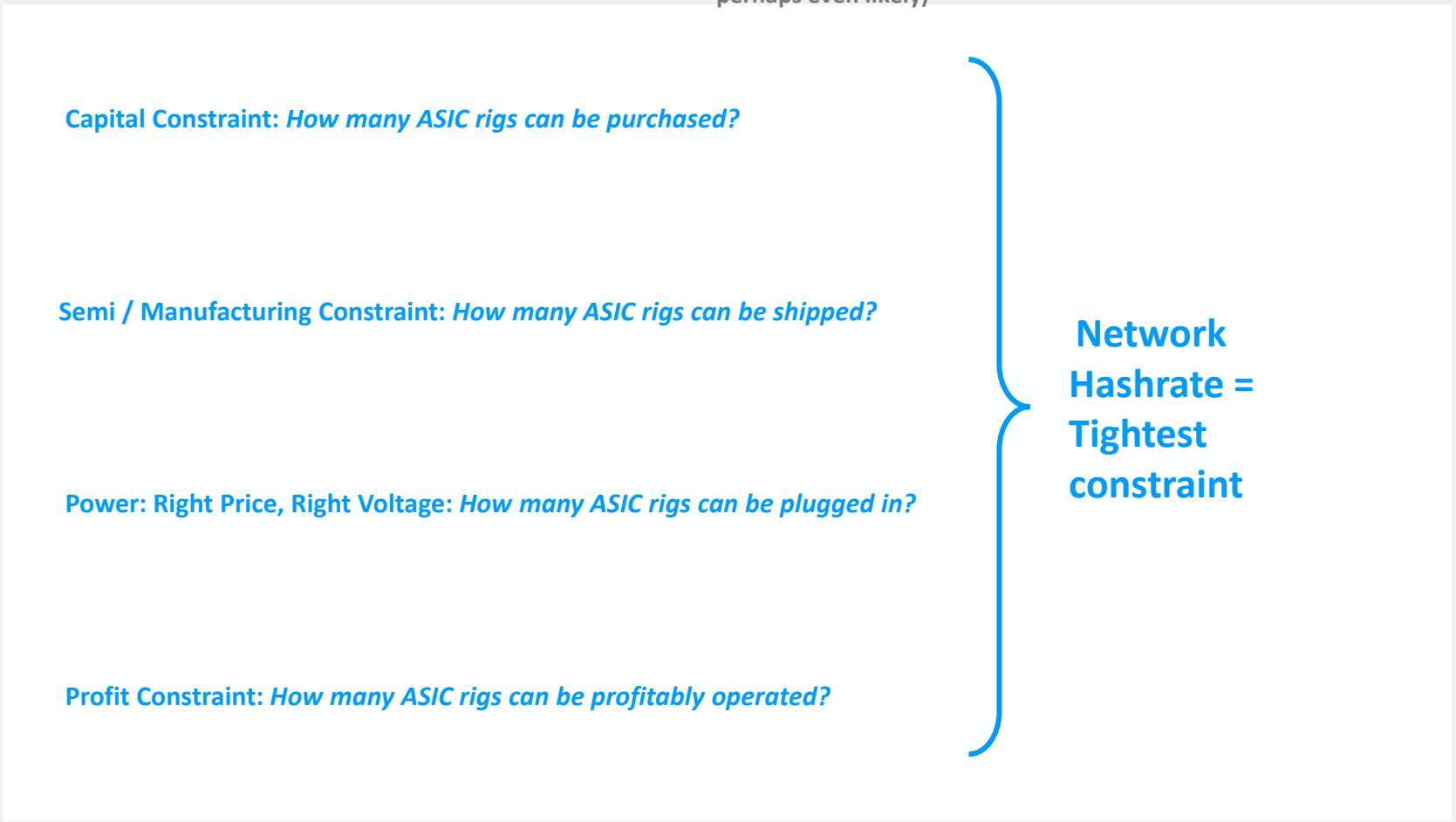


Figure: Constraints driving Bitcoin mining network Hashrate

Source: BitOoda

Capital Constraint

How many ASIC rigs can be purchased?

Strong Economics

Make for Robust Capital Flows

- Access to capital can be a constraint limiting the growth of the network, especially since rig prices have increased over the past year
- Having said that, mining profitability has been well above the historical average over the past year, leading to healthy new capital flows to existing and new miners alike
- Public miners in particular have accessed large amounts of capital
- **Internal cash generation has been strong: daily revenue per PH/s is currently $244**

Figure: Bitcoin mining revenue in USD per PH/s over the past two years

Source: BitOoda, CoinMetrics, Bloomberg

Select Public Miners
Plan to Add 88 EH/s in 2022

- We assess the bulk of public miners constitute about 24EH/s of network capacity, or ~14% of the network Hashrate as of 1/3/22
- These miners intend to increase their Hashrate by ~88EH/s in 2022, based on our reading of various press releases
- The remaining 86% of the current network is also adding capacity
- New miners also continue to enter the space
- **Total network Hashrate is contingent on suppliers' ability to meet commitments – some slippage is possible**

Name	Ticker	Hashrate		
		Current	2022 Deliveries	YE 2022
Argo	ARBK	1605 PH/s	2000 PH/s	3700 PH/s
Bit Digital	BTBT	1603 PH/s	1000 PH/s	2603 PH/s
Bitfarms	BITF	2100 PH/s	5900 PH/s	8000 PH/s
Cathedra	CBIT CN	161 PH/s	566 PH/s	727 PH/s
Cipher	CIFR	0 PH/s	8000 PH/s	8000 PH/s
Cleanspark	CLSK	1300 PH/s	2458 PH/s	3758 PH/s
Core Scientific	XPDI	2640 PH/s	12360 PH/s	15000 PH/s
Digihost	DGHI	0 PH/s	2400 PH/s	2400 PH/s
Greenidge	GREE	1200 PH/s	1900 PH/s	3100 PH/s
Hive	HIVE	2000 PH/s	1000 PH/s	3000 PH/s
Hut8	HUT	1700 PH/s	2800 PH/s	4500 PH/s
Iris Energy	IREN	1452 PH/s	5671 PH/s	7123 PH/s
Marathon	MARA	3200 PH/s	20100 PH/s	23300 PH/s
Mawson	MIGI	800 PH/s	3350 PH/s	4150 PH/s
Northern Data	NB2 GY	660 PH/s	2600 PH/s	3260 PH/s
Riot	RIOT	3000 PH/s	6000 PH/s	9000 PH/s
Stronghold	SDIG	470 PH/s	7600 PH/s	8070 PH/s
Terawulf	WULF	0 PH/s	2100 PH/s	2100 PH/s
	Total	**23891 PH/s**	**87805 PH/s**	**111791 PH/s**

Public miners make up ~14% of current Hashrate

2021 YE

If no other miner added a single rig we would still end 2022 at 261 EH/s

2022 YE

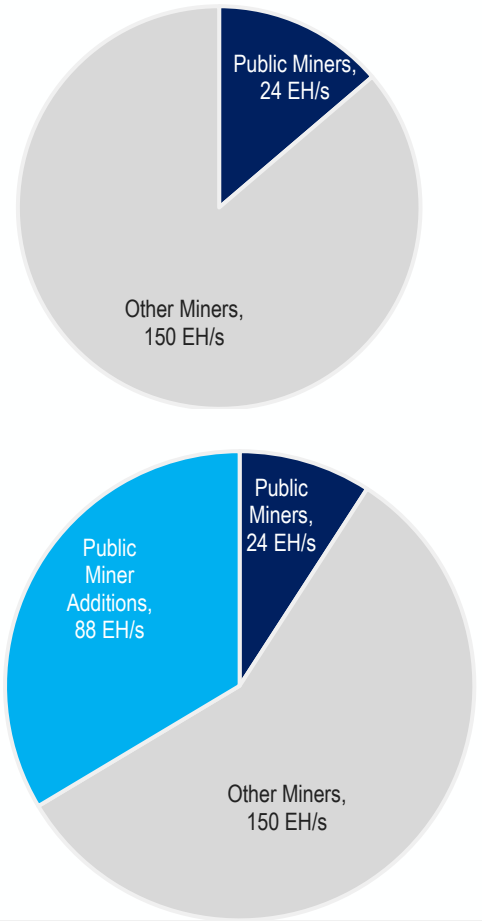


Figure: Public Bitcoin miner Hashrate per public announcements as of 1/3/2022

Source: BitOoda estimates, CoinMetrics, Bloomberg

Miners Make $293 Per MWh Using Latest Gen Rigs

- Miners using latest generation S19-class mining rigs currently earn $293 per MWh, which is in the 65th percentile compared to the past 2 years
- Over the same period, the mean / median daily earnings have been $197 and $161, respectively

Figure: Bitcoin mining revenue in USD per MWh using then-current gen rigs over the past two years

Source: BitOoda, CoinMetrics, Bloomberg

$227 Hash Spread Per MWh
Using Latest Gen Rigs

- Current Hash Spread is $227 per MWh, in the 62nd percentile compared to the past 2 years
- Over the same period, the mean / median daily earnings have been $170 and $130, respectively
- The average Hash Spread in 2021 was $248.95, up from $70.23 in 2020
- **This drives a significant amount of internal capital generation for reinvestment, and also attracts fresh capital**

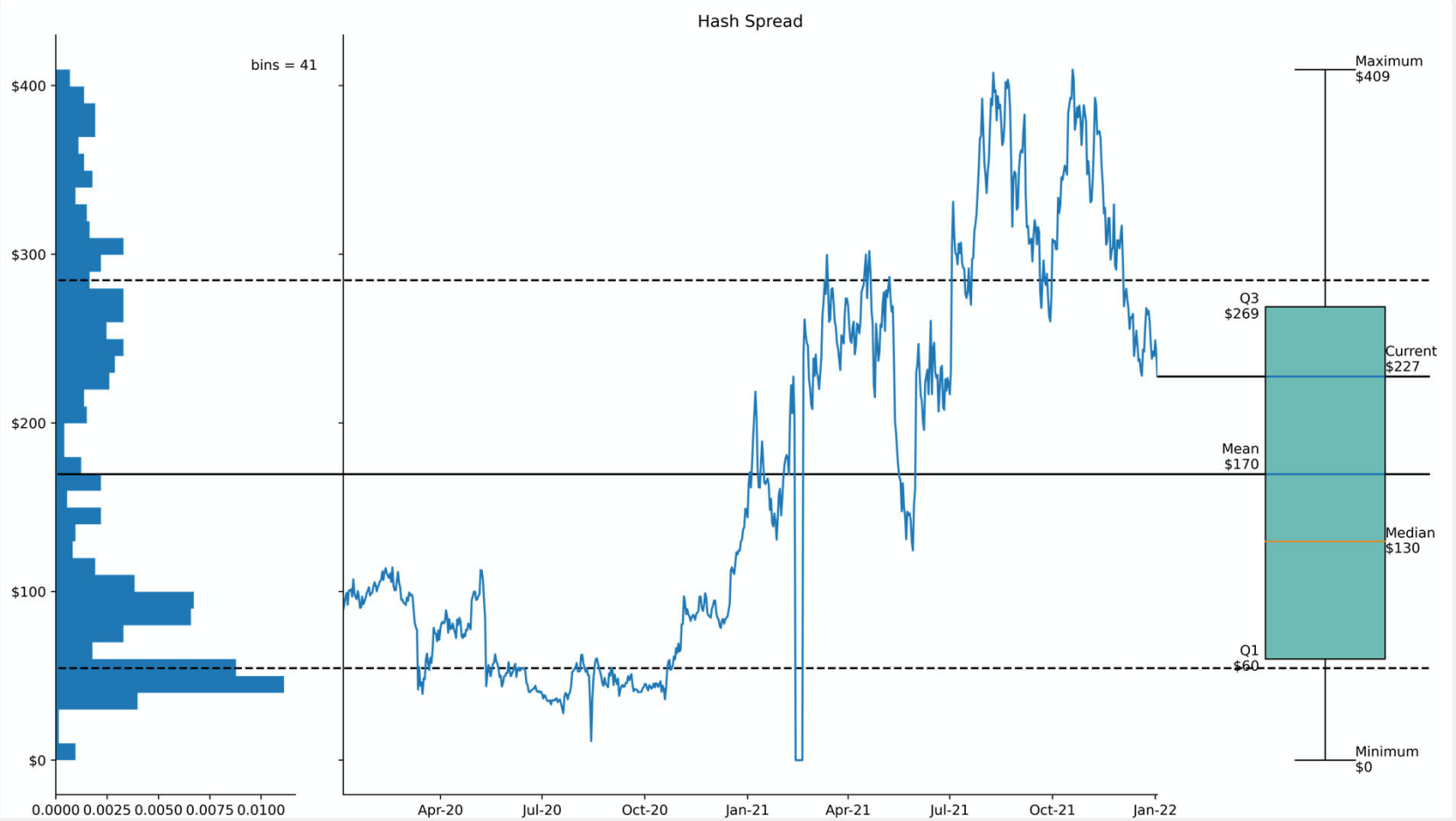


Figure: Hash spread per MWh using then-current gen rigs over the past two years

Source: BitOoda, CoinMetrics, Bloomberg

Miner Capital Generation

Other Miners *Could* Add 120 EH/s in 2022

- The average Hashrate for 2021 was 145EH/s
- Deducting ~12EH/s (half YE Hashrate) for the public miners, other miners averaged 133 EH/s, drawing ~5.5GW power
- We estimate a blended Hash spread of $176 for the year; $166/ MWh after direct labor. We assume $150/MWh **after maintenance costs and replacement capex**
- Thus, the private miners generated $7.2 billion of reinvestable capital
- At $120 / TH/s, including ancillary power equipment, these other miners could add 60 EH/s; fresh capital inflows could double that

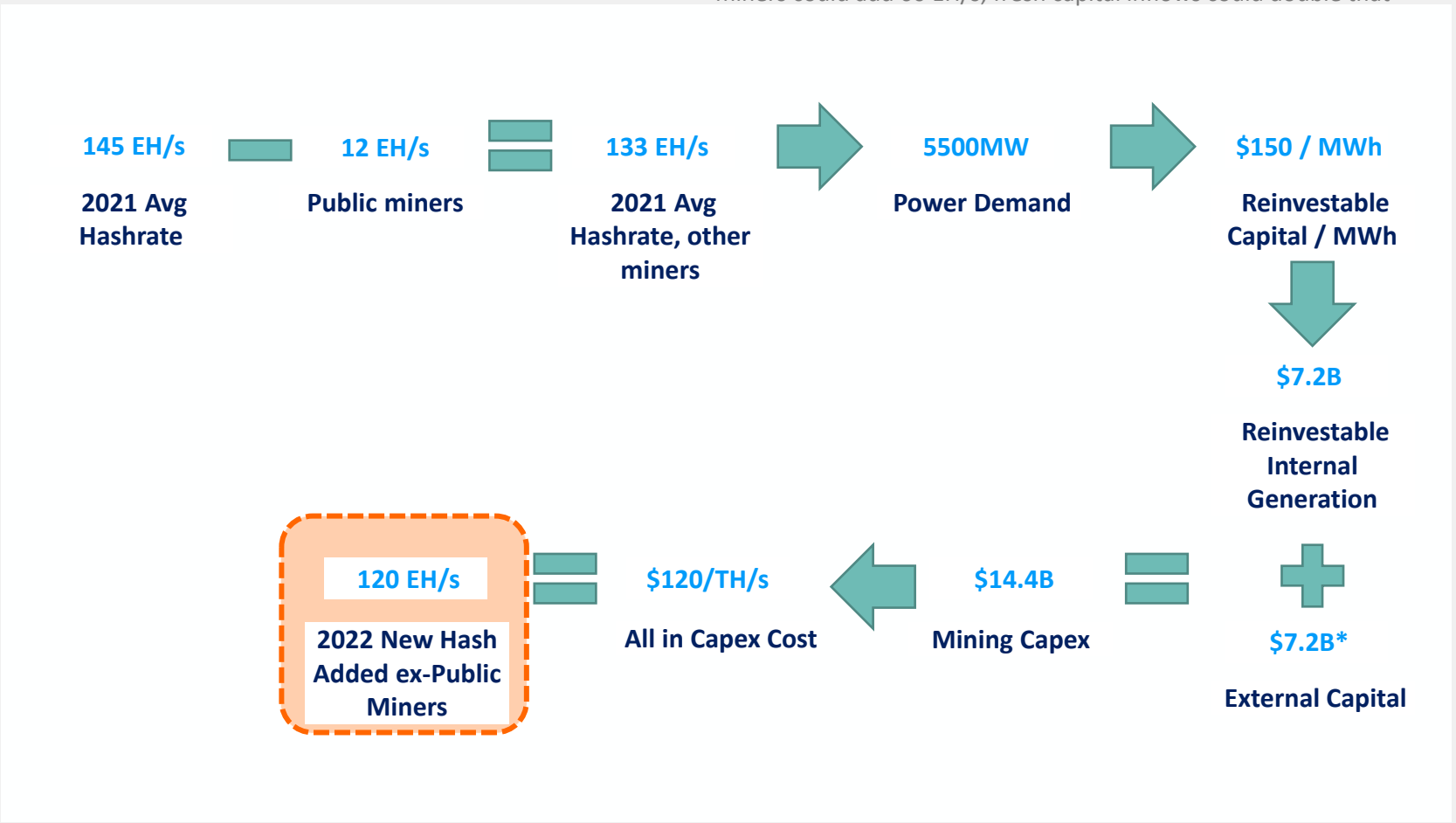


Figure: Miner capital generation and Hashrate additions in 2022
Note: external capital flows to non-public miners represent reasonable estimates

Source: BitOoda estimates, CoinMetrics, Bloomberg

Capital Constraint:
382 EH/s is Plausible by YE 2022

- We assume no major delays with shipping and installation of rigs
- We assess that about 380 EH/s ending network Hashrate is supportable by announced public miner investments, other miner capital generation and fresh capital flows
- Our assumption of a $120 / TH/s all in capex cost is probably high, giving wiggle room in the event capital flows fail to match expectations
- **382 EH/s is a very plausible scenario for year end 2022 Hashrate provided other constraints do not apply, including no retirements of older-gen rigs**

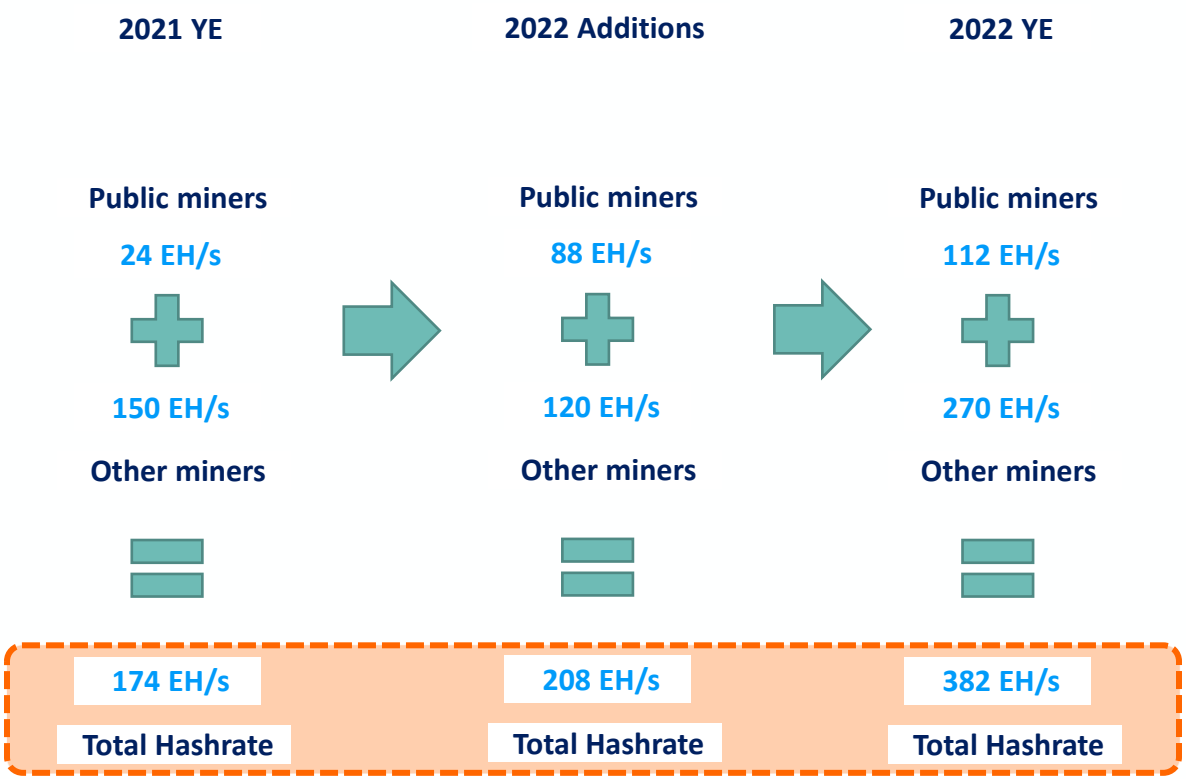


Figure: Plausible Bitcoin mining network Hashrate, 2022 year end

Source: BitOoda estimates, CoinMetrics, Bloomberg

Semiconductor Constraint

How many ASIC rigs can be shipped?

Technology Convergence Slows ASIC Efficiency Improvements

- Network Hashrate exploded as rig makers took advantage of older semiconductor capacity as foundries migrated to newer processes
- Lags between new process introduction and rig development have largely vanished, while process evolution is slowing as well
- Rig makers are now vying for the same limited capacity against the majors
- We assess further design efficiencies can be gained – it is not all node shrink
- **Further, the small, simple and repetitive design of an ASIC die lends itself to early capacity allocation as foundries seek to perfect new production processes**

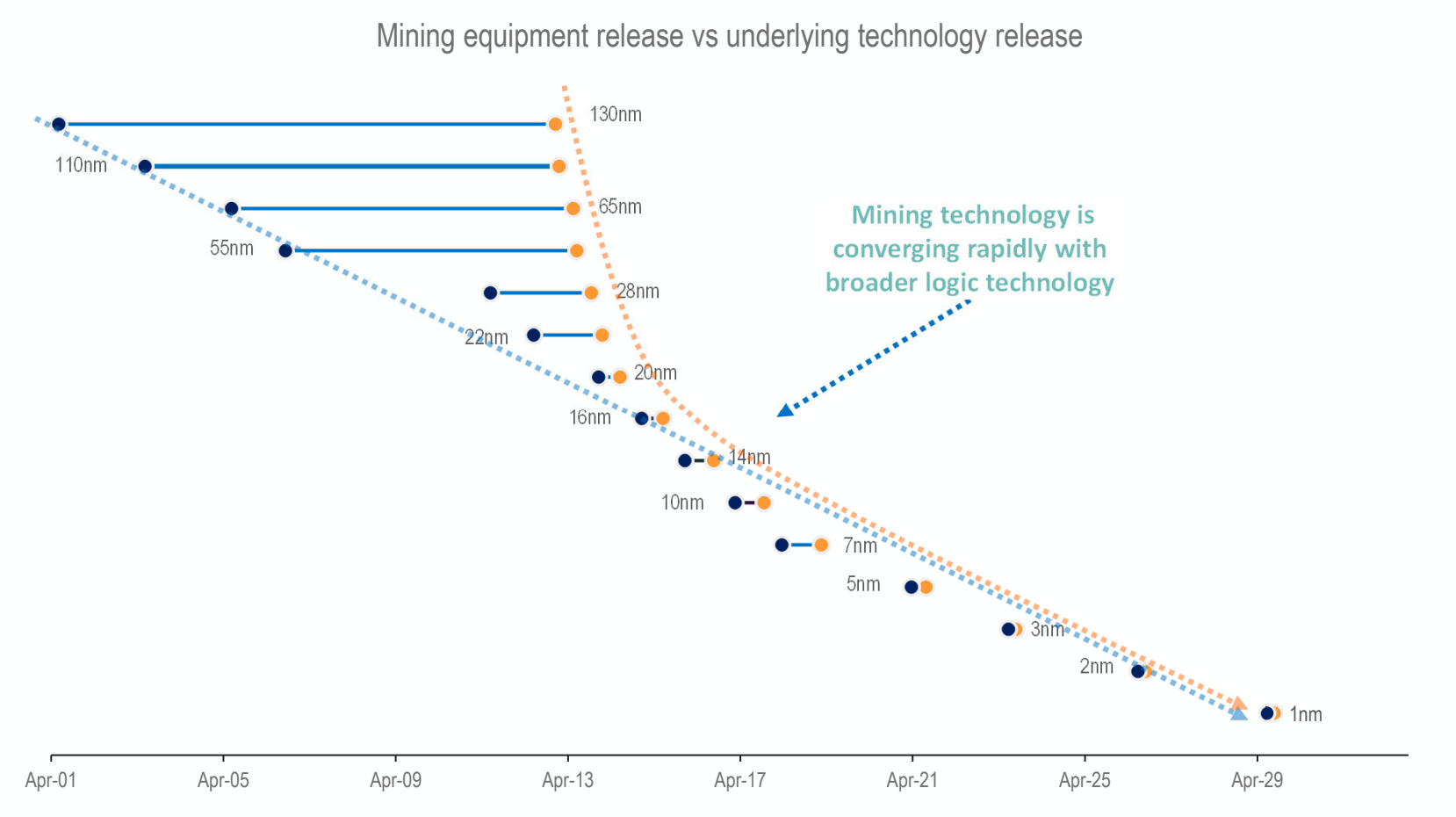


Figure: Left dot denotes date of technological advancement, right shows initial incorporation into BTC ASICs. Y-axis not to scale

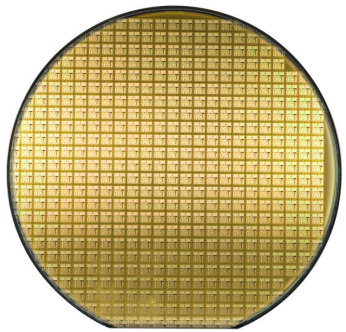
Source: BitOoda, wikichip.org

Rig Class Assumptions

Future Rigs Could Have More, Smaller Chips

- We believe the Hashrate per wafer could more than double over the next decade compared to the S19-class Hashrate
- This is still a slowing rate of improvement, which might prove conservative
- However, our belief is the actual linewidth and feature shrink will lag the nominal process shrink
- We believe die sizes may shrink modestly to enhance yields, resulting in more chips per device
- This does not account for changing design paradigms around direct immersion of hashboards, which may develop sooner than later

Class	Release Date	Hashrate / mm²	Power cons / mm²	Die Size mm²	Dies / Wafer	Hashrate / Wafer	Chips / Device	Devices / Wafer	Power Cons / TH	Power cons / Wafer
S9	9/1/2016	6 GH/s	0.57 W	12	5089	377 TH/s	189	26.9	92.3 W	34.8 kW
S17	4/1/2019	14 GH/s	0.62 W	25	2442	848 TH/s	144	17.0	44.4 W	36.2 kW
S19	5/11/2020	17 GH/s	0.56 W	23	2655	1048 TH/s	228	11.6	32.6 W	34.2 kW
S19XP	8/1/2022	26 GH/s	0.52 W	20	3053	1583 TH/s	270	11.3	20.3 W	31.8 kW
5nm+	10/1/2022	30 GH/s	0.51 W	18	3392	1837 TH/s	300	11.3	17.0 W	31.1 kW
3nm	9/1/2023	35 GH/s	0.50 W	18	3392	2131 TH/s	300	11.3	14.3 W	30.5 kW
2nm	9/1/2026	40 GH/s	0.49 W	16	3817	2450 TH/s	330	11.6	12.2 W	29.9 kW
1nm	9/1/2029	45 GH/s	0.48 W	15	4071	2756 TH/s	360	11.3	10.6 W	29.3 kW



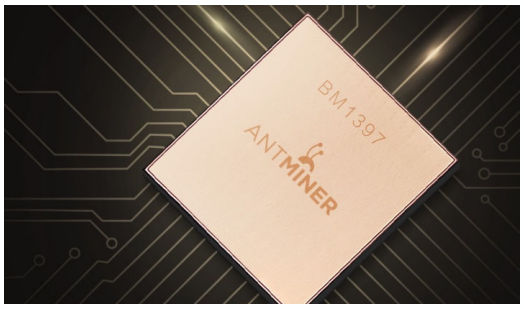


Figure: Chip parameters for key generations

Source: BitOoda estimates, CoinMetrics, Bitmain
https://jimmysong.medium.com/just-how-profitable-is-bitmain-a9df82c761a

Semi Node Shrink
Improves Hashrate Density

- We believe ongoing node shrink should continue to drive improving Hashrate efficiency per unit area of each semiconductor wafer
- Power consumption per unit area could stay flat to increase modestly
- This is a design choice, to optimize Hashrate rather than focus on power consumption – i.e., the tradeoff is between more Hashrate at the same power consumption, or less power consumption at the same Hashrate
- These are reasonable approximations rather than scientific estimations

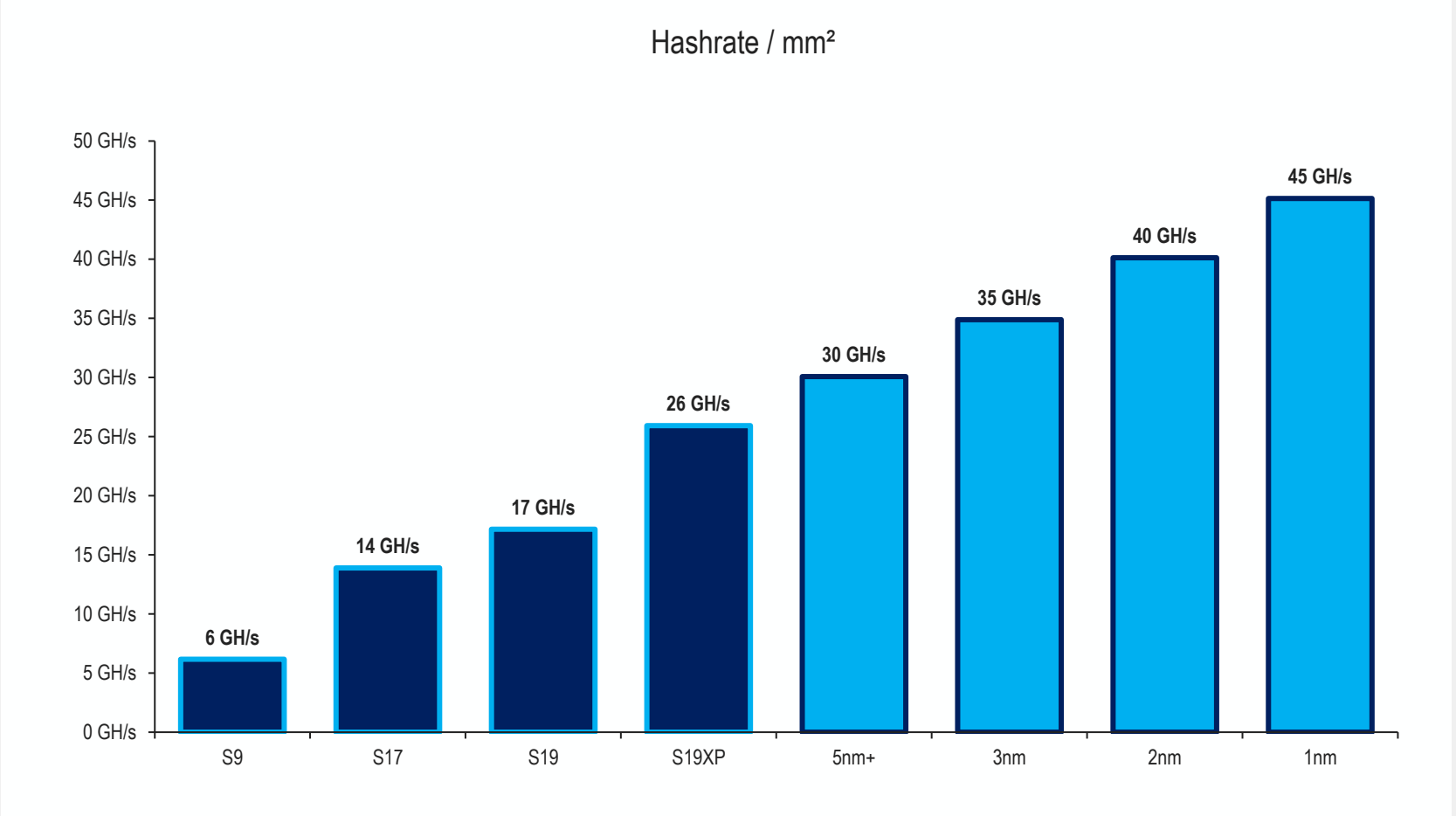


Figure: Device stats for current and future rig classes
Hashrate per mm^2 is the key metric: device Hashrate is a design choice based on chip count, chip size, and Hashrate per mm^2

Source: BitOoda estimates, CoinMetrics
Note: in our view, 5nm+ class of rigs represent an optimized design as 5nm production processes continue to improve

Over Time

Number of Devices per Wafer Should Stabilize

- We assess that over time, the number of devices produced per wafer should stabilize around current levels
- However, there may ultimately be a paradigm shift in that immersion could allow for more, standalone hashboards
- As a result, Hashrate per wafer may be a more reliable, design-choice-independent metric

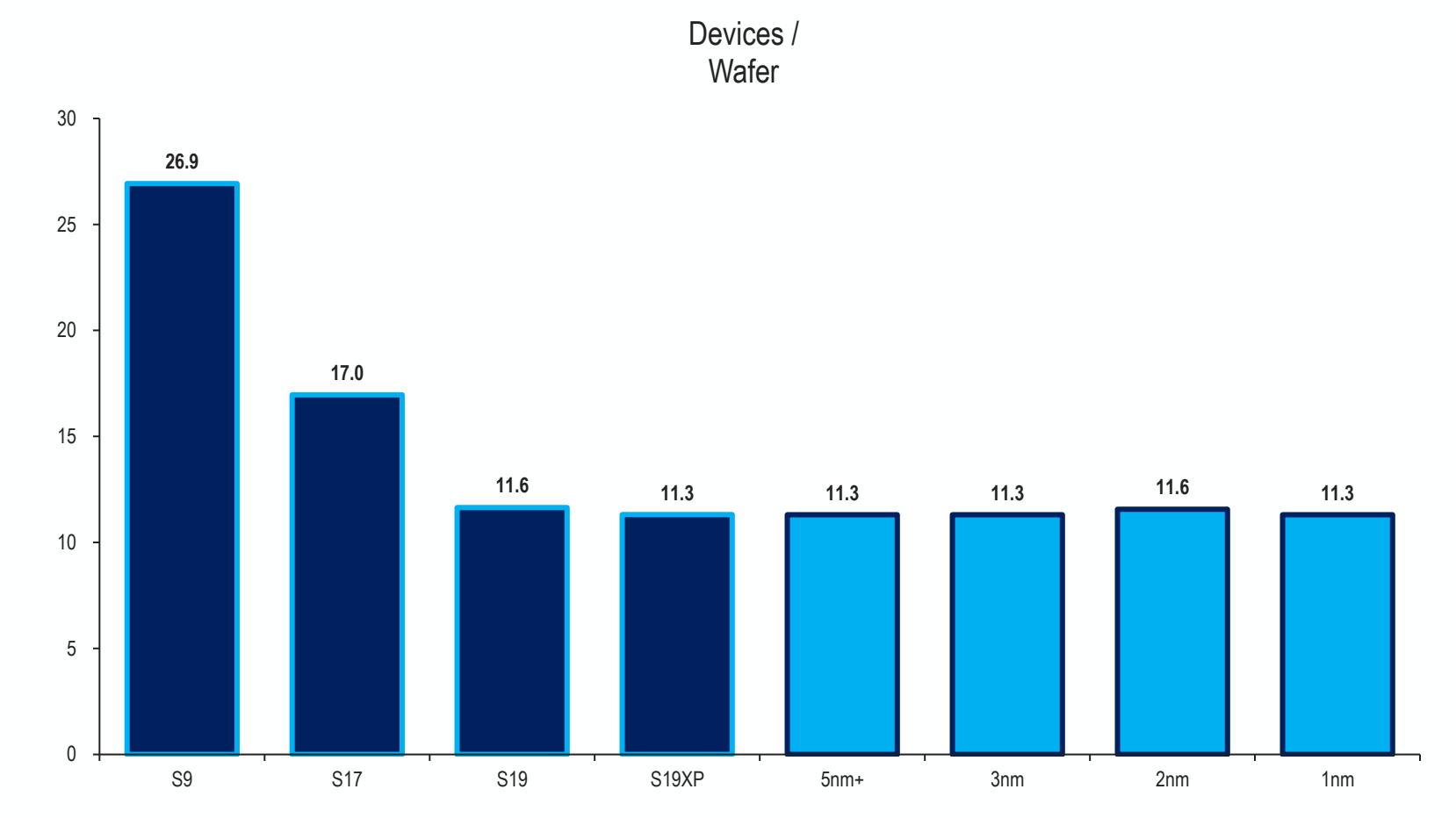
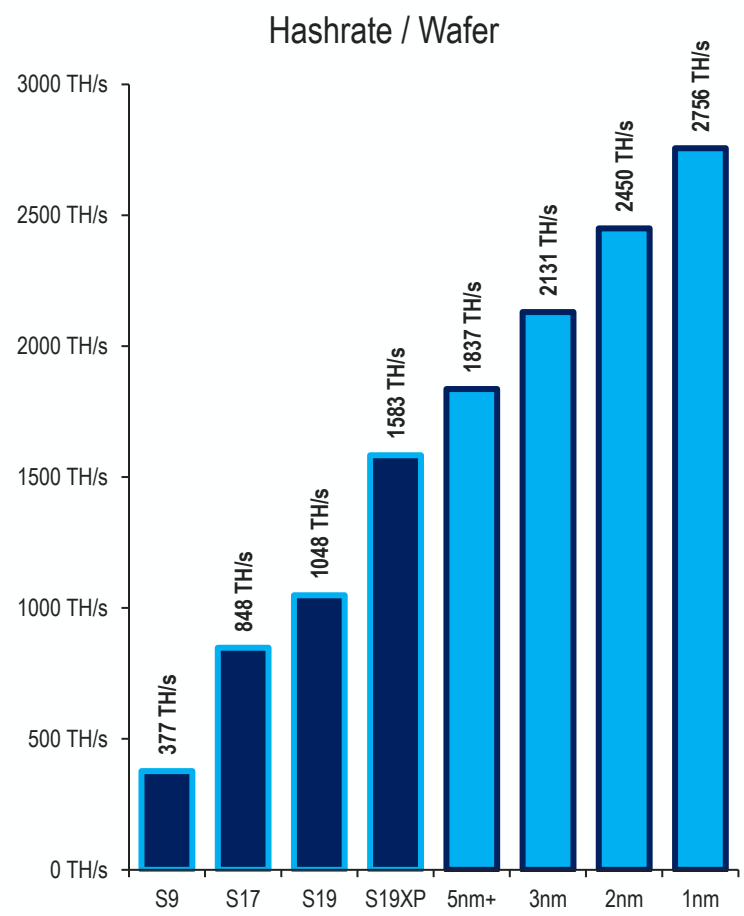


Figure: Device count per wafer for current and future rig classes

Source: BitOoda estimates, CoinMetrics
Note: in our analysis, 5nm+ class of rigs represent an optimized design as 5nm production processes continue to improve

Increasing Wafer Hashrate
With Flattish-to-Down Power

- Hashrate/Wafer increases steadily with node shrink and hardware design improvements
- Hashrate/Wafer could increase to 2,756 TH/s per wafer with 1nm chips, more than double today's level
- Power consumption/wafer should remain relatively similar through 2030, falling modestly over time
- Note that TSMC projects the 3nm node, still using FinFET transistors, will deliver 70% logic density gains, 15% speed and 30% less power consumption compared with 5nm, supporting our approximations



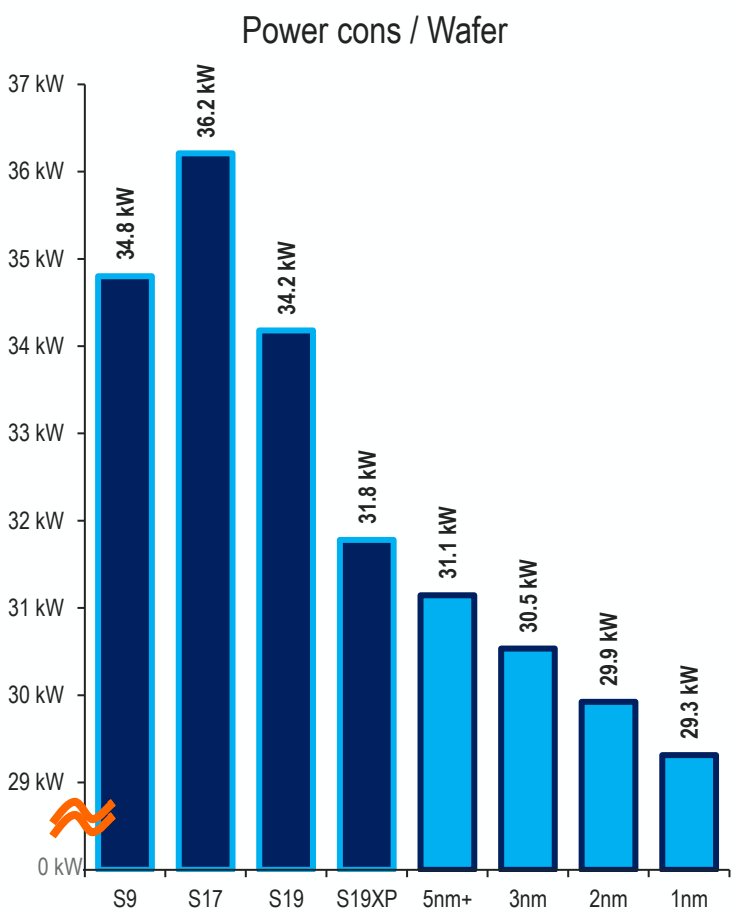


Figure: Current and projected Hashrate and power consumption per wafer

Source: BitOoda estimates, Coinmetrics

Our Theoretical Rig Hashrate
Could Reach ~240 TH /S

- We utilize a 14A current limit, and factor power drawn for fans, controllers / other chips and the rest of the rig bill of materials to get the total available power for ASIC chips
- We continue to use the three-hashboard paradigm, although immersion systems will likely result in different configurations
- This leads to an estimate of device Hashrate rising to 190 TH/s over this decade, and thus our estimate of rigs sold, based on wafers and rigs per wafer
- The actual number of rigs sold and the Hashrate per rig is simply a design choice: how many of these dies do you design into a single rig?

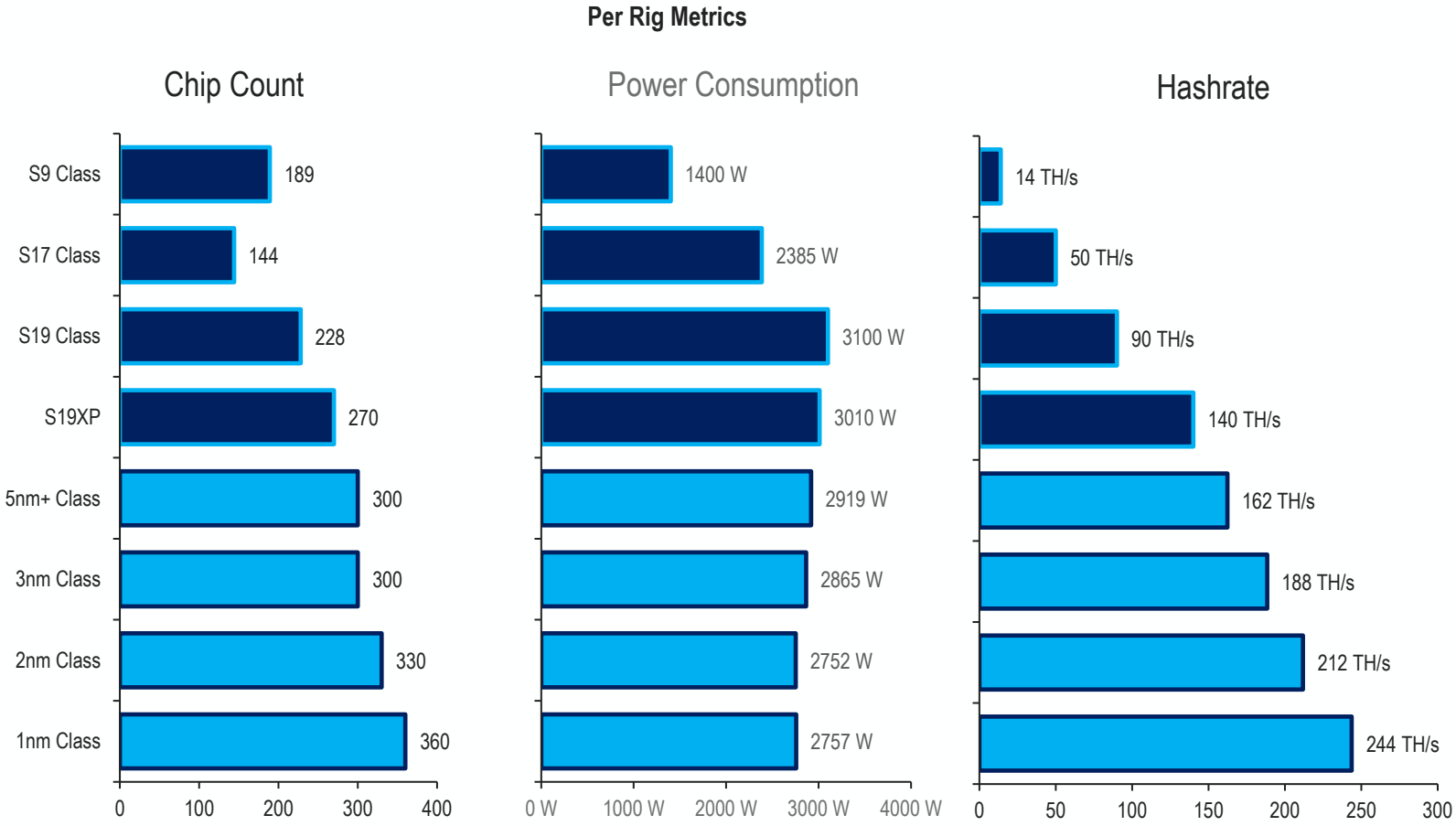


Figure: Device stats for current and future rig classes

Source: BitOoda estimates

Device Shipments
Implied by Hashrate Growth

- Using historical Hashrates, as well as data on historical miner specifications, we estimate device shipments
- We assume that about 50EH/s of rigs went permanently offline in 2021, roughly half the Hashrate in China before the ban

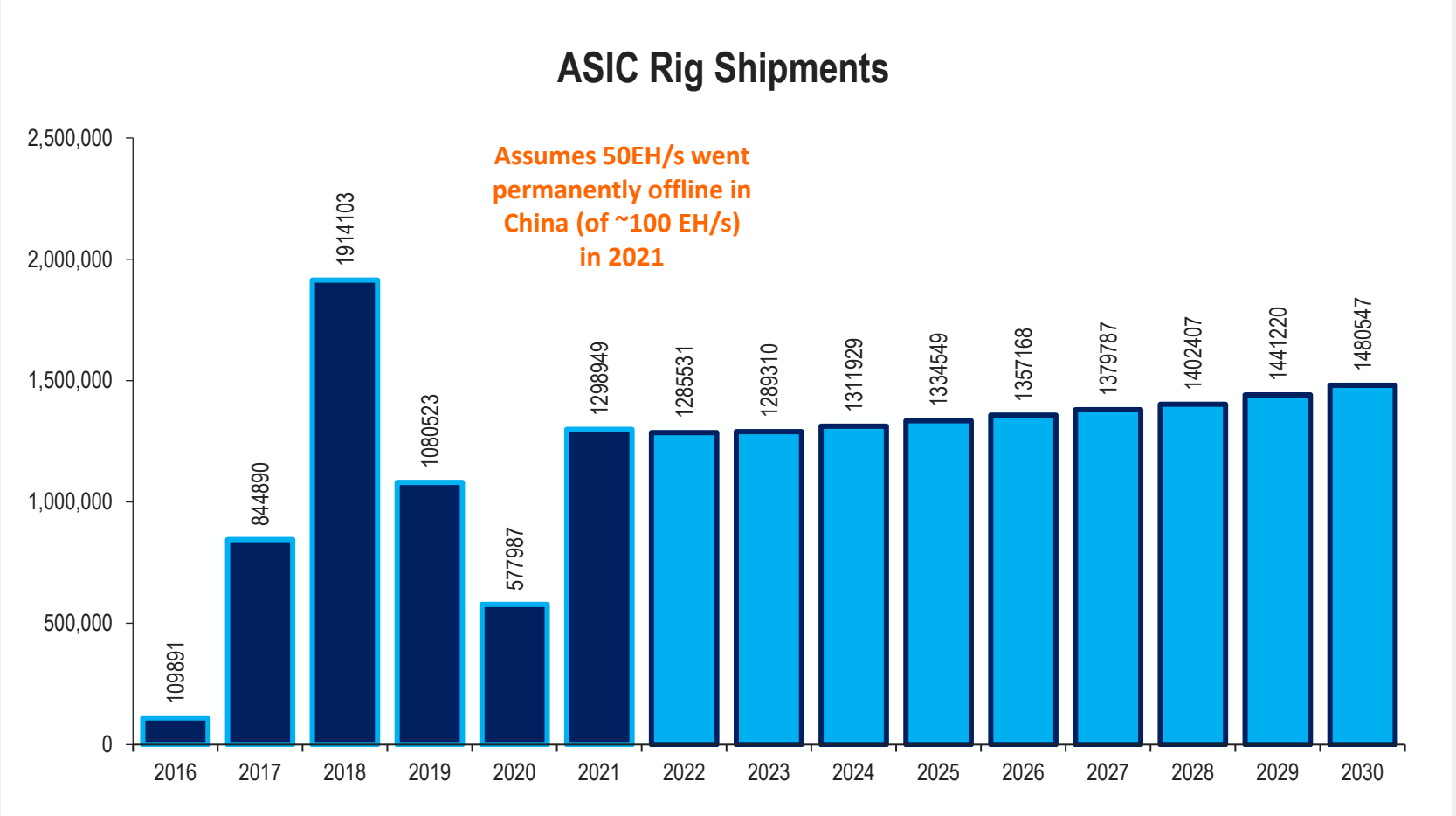


Figure: Device shipments implied by Gross Hashrate growth each year

Source: BitOoda estimate, Coinmetrics, Bloomberg

Annual Wafer Starts
Implied by Unit Shipments

- We estimate the number of wafers needed to produce the rigs for the gross Hashrate added each year
- Gross Hashrate added equals net increase in Hashrate as well as retirement of old equipment through failure or obsolescence
- We measure wafer equivalents when delivered rather than when started / manufactured, to line up with deployments
- Hardware and semiconductor shortages have constrained the market for devices

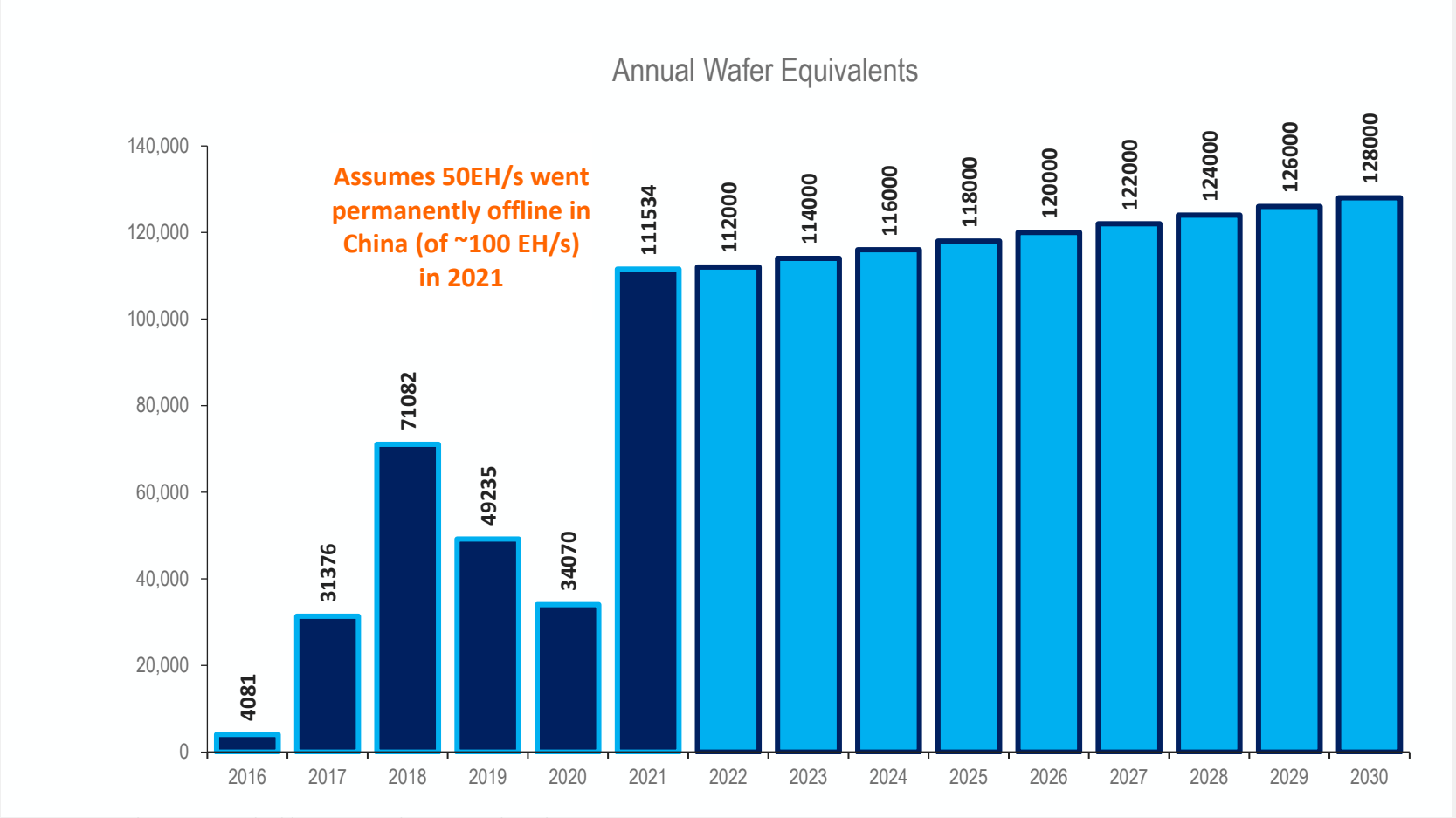


Figure: Device shipments implied by Gross Hashrate growth each year

Source: BitOoda estimate, Coinmetrics, Bloomberg

TSMC 3Q2021 Results
3.6mm 12” eq. Wafers Shipped

- TSMC shipped 3.6 million 12” equivalent wafers in Q3 2021
- TSMC’s average revenue was $4,081 per 12” wafer across all process nodes
- TSMC is the dominant player in 7nm and 5nm processes, with Samsung in second place

tsmc
Unleash Innovation

Statements of Comprehensive Income

Selected Items from Statements of Comprehensive Income

(In NT$ billions unless otherwise noted)	3Q21	3Q21 Guidance	2Q21	3Q20	3Q21 Over 2Q21	3Q21 Over 3Q20
Net Revenue (US$ billions)	14.88	14.6-14.9	13.29	12.14	+12.0%	+22.6%
Net Revenue	414.67		372.15	356.43	+11.4%	+16.3%
Gross Margin	**51.3%**	**49.5% - 51.5%**	**50.0%**	**53.4%**	**+1.3 ppts**	**-2.1 ppts**
Operating Expenses	(41.65)		(40.58)	(40.89)	+2.6%	+1.9%
Operating Margin	**41.2%**	**38.5% - 40.5%**	**39.1%**	**42.1%**	**+2.1 ppts**	**-0.9 ppt**
Non-Operating Items	2.85		3.72	5.07	-23.5%	-43.9%
Net Income to Shareholders of the Parent Company	156.26		134.36	137.31	+16.3%	+13.8%
Net Profit Margin	**37.7%**		**36.1%**	**38.5%**	**+1.6 ppts**	**-0.8 ppt**
EPS (NT Dollar)	6.03		5.18	5.30	+16.3%	+13.8%
ROE	30.7%		27.3%	31.3%	+3.4 ppts	-0.6 ppt
Shipment (Kpcs, 12"-equiv. Wafer)	3,646		3,449	3,240	+5.7%	+12.5%
Average Exchange Rate--USD/NTD	27.87	27.90	28.01	29.36	-0.5%	-5.1%

* Diluted weighted average outstanding shares were 25,930mn units in 3Q21.

** ROE figures are annualized based on average equity attributable to shareholders of the parent company.

Figure: TSMC 3Q2021 results show 3.6 million 12” equivalent wafers shipped

Source: TSMC

TSMC 3Q2021 Results
>50% of Revenue from 7nm and Below

- We assess Bitcoin ASIC demand of 112k wafers represents low-single digit percentage of sub-10nm wafer capacity
- TSMC represents about 90% of sub-10nm wafer capacity, with Samsung representing the rest
- We believe the realizations for 7nm and 5nm wafers are between $7-10k, down from the $10-12.5k in 2019 estimated by IBS Research
- **This would put the die cost in an S19j / S19XP at $600 and $900, respectively**
- This does not include back-end packaging, testing and the PCBs, other components, power supply, fans and box, but the chips are the largest expense

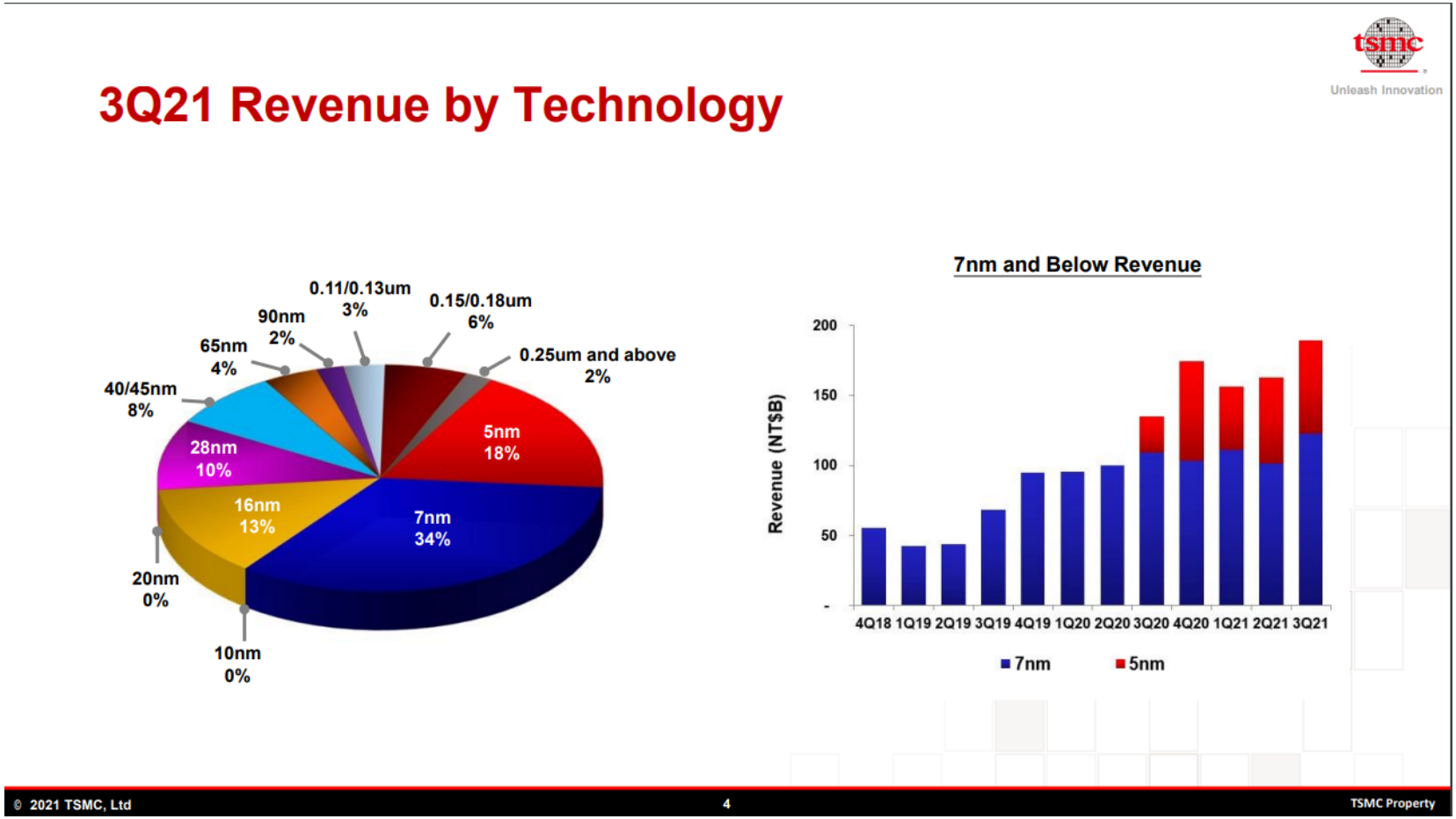


Figure: TSMC 3Q2021 revenue breakdown by process technology

Source: TSMC

Semi Constrained Network Hashrate: 327 EH/s by 2022 YE

- Based on the availability and deployment of ASIC rigs, we believe a 327EH/s Hashrate by the end of 2022 is feasible
- Based on the foregoing discussion, total network Hashrate could rise to ~1,647 EH/s by the end of 2030, provided capital, power and profitability are supportive

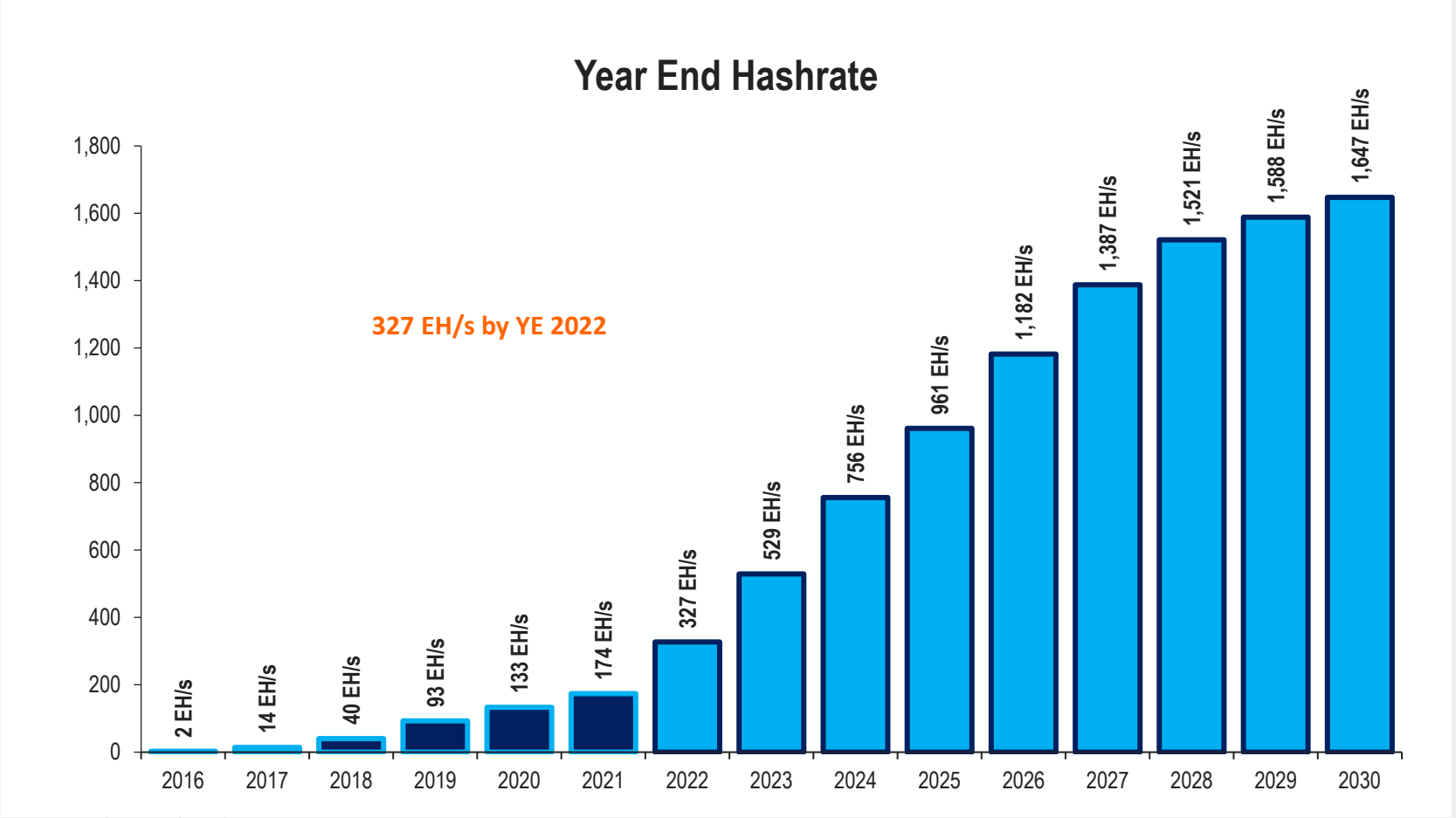


Figure: Total Network Hashrate

Source: BitOoda estimates, CoinMetrics

Cross Checking Estimates:
Bottom- Up Aligns Closely with Actual Hash Growth

- We were surprised by how low our wafer starts estimates are, so we explored some known data to triangulate
- We know S9s contain 189 chips and we have seen estimates of a 12mm die size
- Based on this, we can estimate about 27 rigs per 300mm wafer
- Our estimated 71,000 wafer starts lead to 1.92mm S9-class shipments
- This equates to approximately 26.8 EH/s of Hashpower shipped to the network
- In comparison, the actual net Hashrate added over 2018 was 26.3 EH/s
- We estimate the gross Hashrate added was 26.8 EH/s (Net Hashrate growth + some replacement Hashrate for old rigs)

The bottom up Hashrate add estimate aligns closely with the actual top-down measure

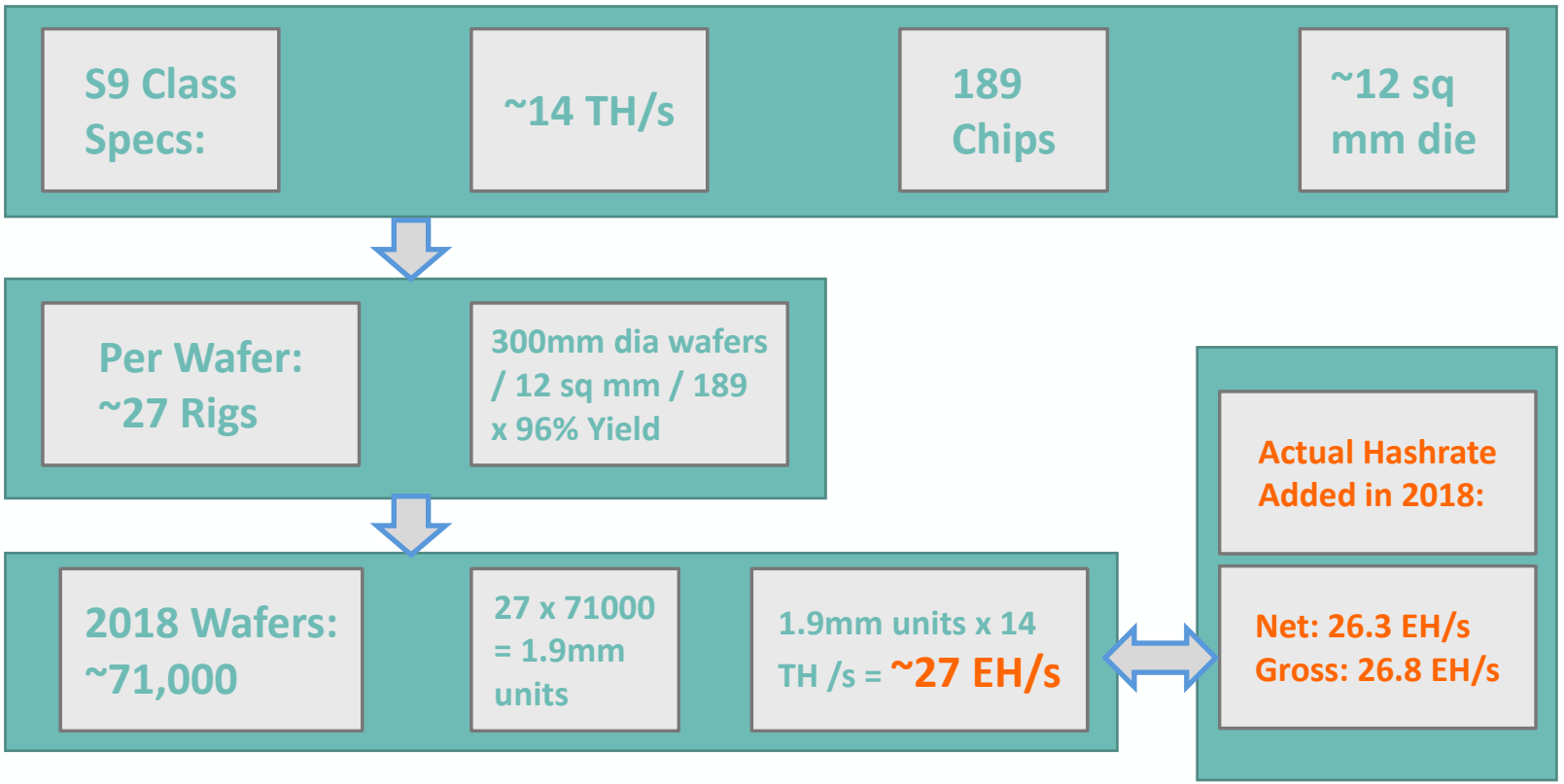


Figure: Cross checking our bottom-up estimates against actuals

Source: BitOoda estimates

Power Constraint

How many ASIC rigs can be plugged in?

MWh per BTC Mined
Currently 174 MWh

- As network Hashrate increases, it takes an increasing amount of power to produce 1 BTC
- Currently, it takes over 500 MWh to produce a BTC with S9-class machines, and 174 MWh with S19-class machines
- The energy intensity is high and growing, and has clearly attracted environmental and regulatory scrutiny
- However, we do believe there is a role for Bitcoin mining within an ESG-forward framework – where Bitcoin mining is not just benign or neutral, but an active component of an ESG renewables strategy

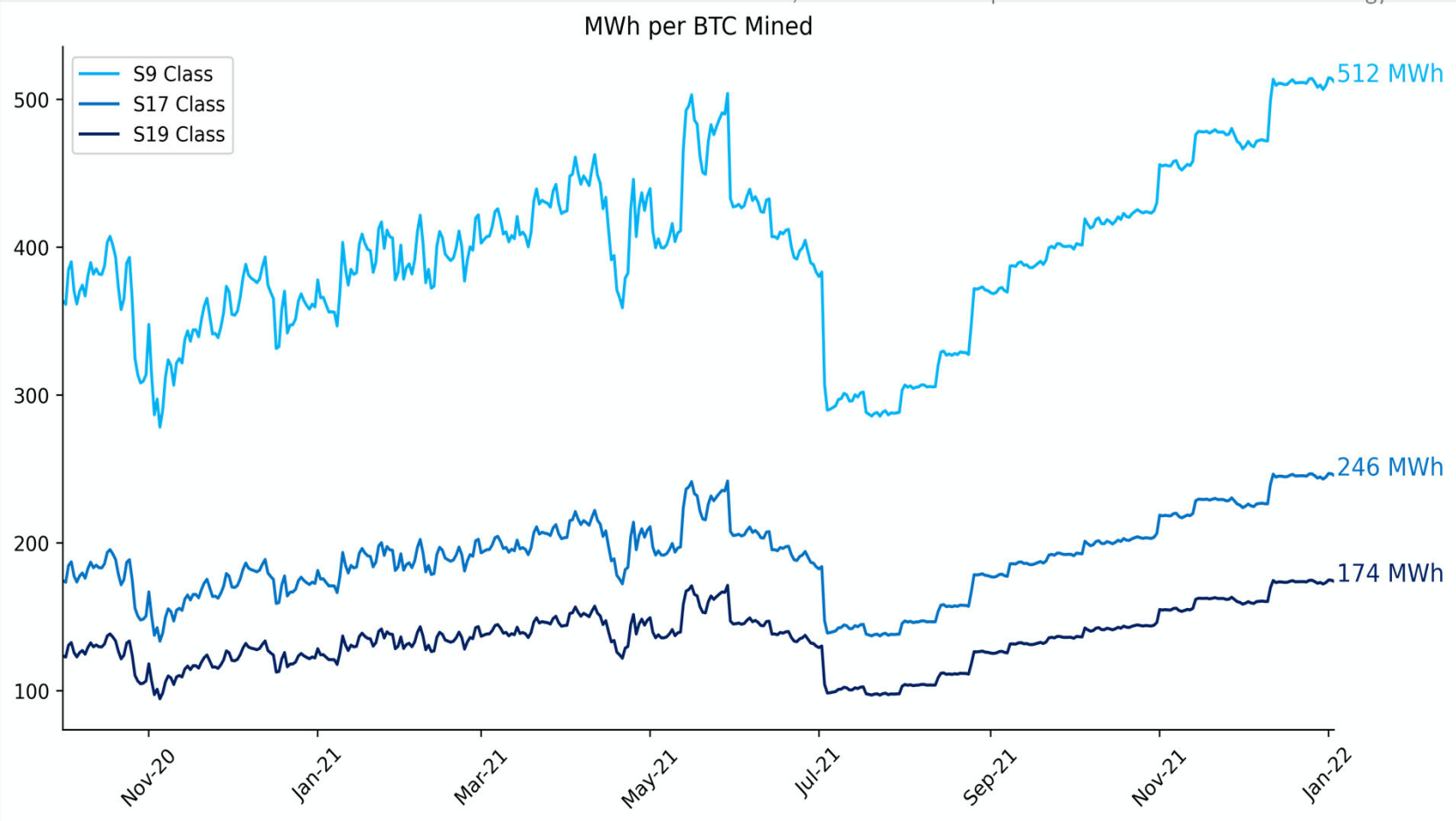


Figure: MWh per BTC Mined by device class

Source: BitOoda, CoinMetrics, Bloomberg

2022 Growth Plans

Call for > 4GW of Power Additions

- We assess that Bitcoin mining plants under development add up to well north of 5GW of capacity
- However, we consider delays for long lead items such as transformers and sub stations will likely cause some slippage
- Thus, we assume about a 4GW addition to the network for this year
- This comes off a minimal increase this year, as a mix shift drove Hashrate growth as older machines, especially in China, were retired
- **However, we see no reason 5GW or more could not be added each year, if the miner economics supported it**

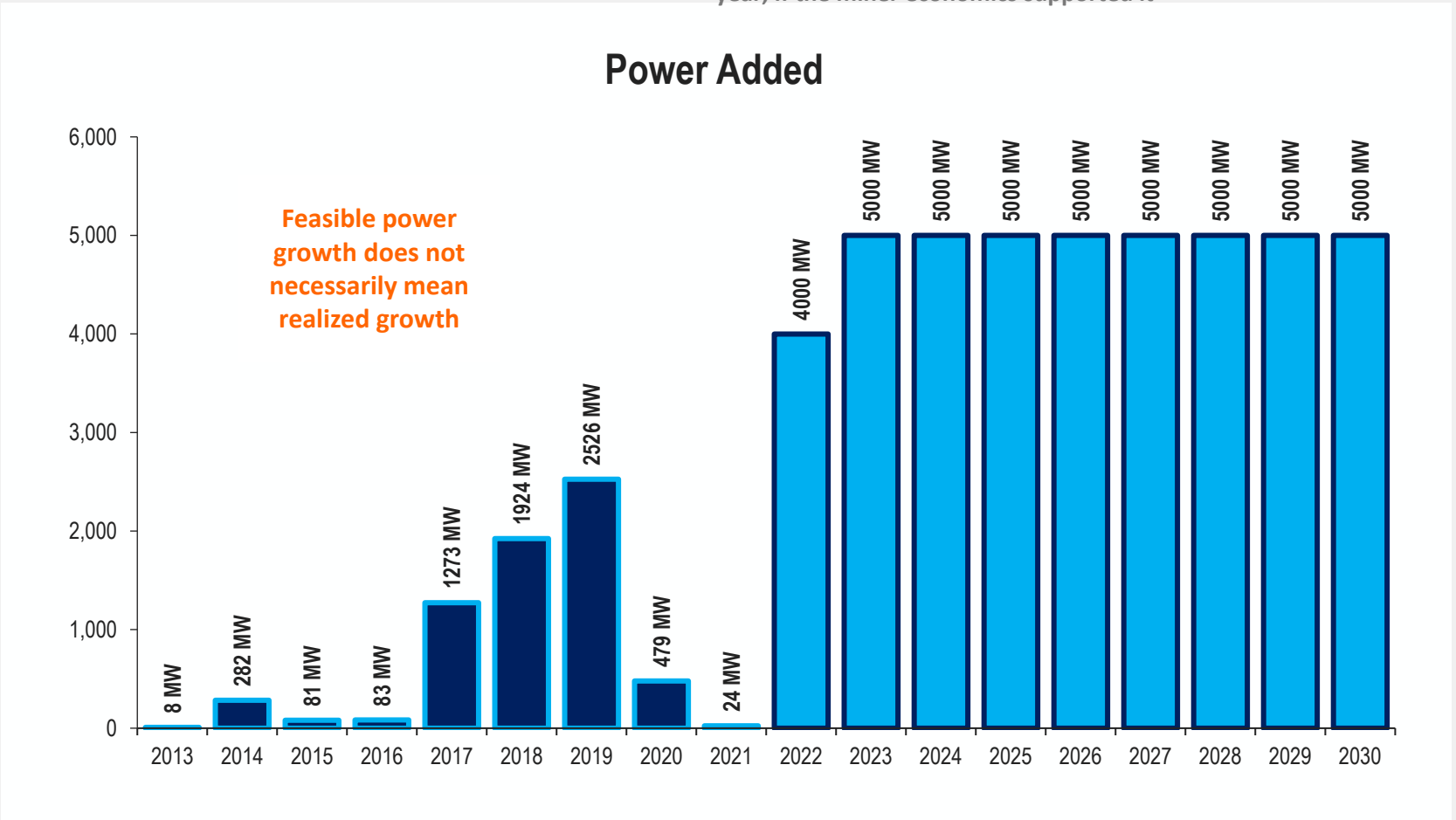


Figure: MW capacity added to the Bitcoin network each year

Source: BitOoda estimates, CoinMetrics, Bloomberg

This Could Lead to
Over 50GW by 2030

- Could a 50GW Bitcoin mining network make sense?
- Yes, if Bitcoin price and growth in transaction fees supported it
- We believe that Bitcoin mining can be a key component of a multi-pronged interruptible computational load initiative designed to mitigate intermittency issues on the grid as it transitions to renewables faster than storage technologies can keep up economically
- We qualify this statement with the proviso that economics are maintained and the regulatory environment is benign

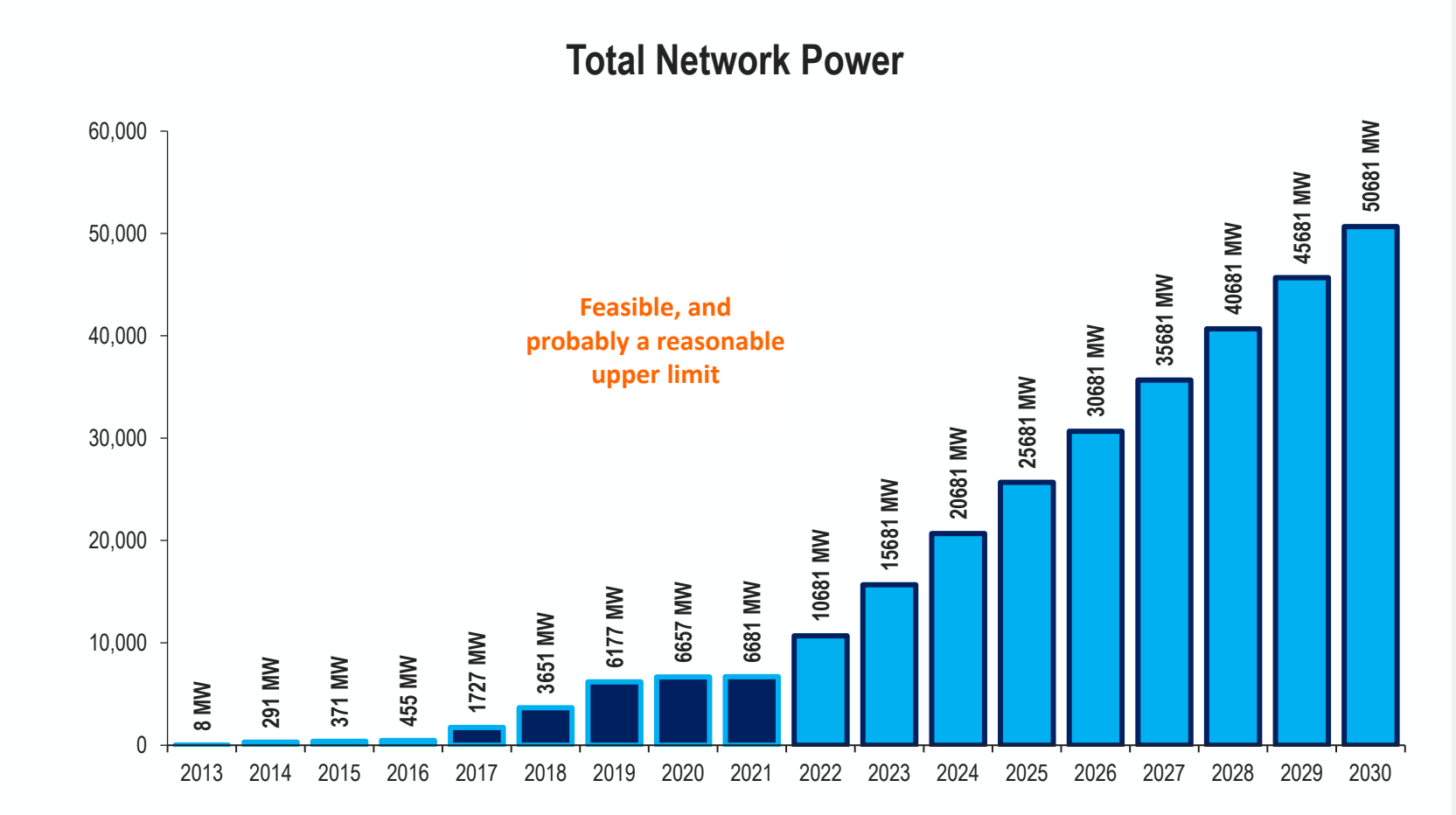


Figure: Total Bitcoin mining network power consumption

Source: BitOoda estimates, CoinMetrics, Bloomberg

Marginal Hashrate Is Added at Most Efficient Machines

- We assume that the incremental Hashrate always comes from a mix of the latest efficiency class
- The mix shifts from the older-gen machines to next-gen over the course of 3 months from the release of the next-gen class
- This is what we use to compute Hashrate added as a function of MW capacity growth

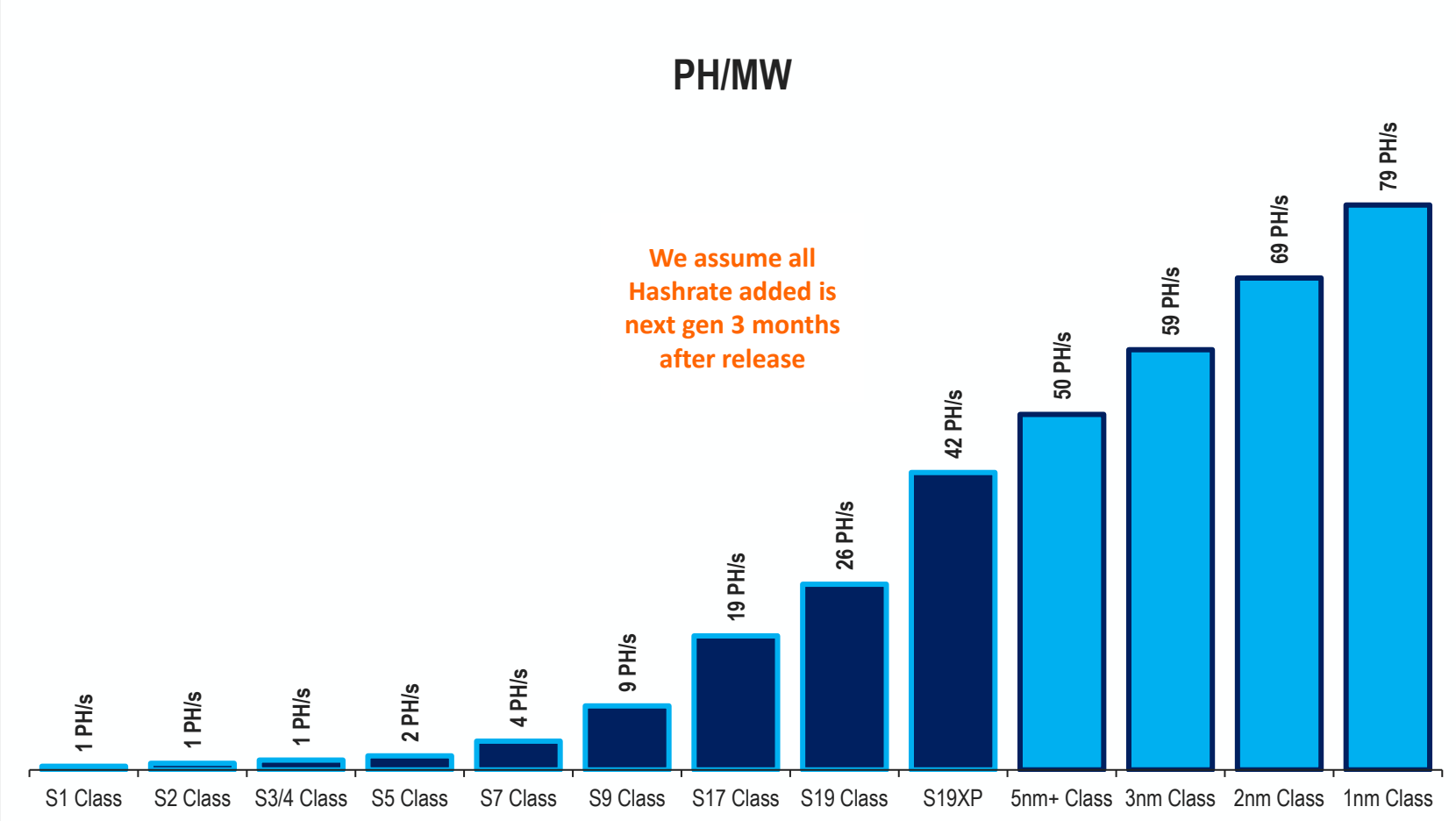


Figure: Hashrate added each year to fill the added power capacity

Source: BitOoda estimates, CoinMetrics, Bloomberg

2021 Added 41EH/s
2022 Could Add 160 EH/s

- Network Hashrate in 2021 grew by just 41EH/s but by a lot more under the surface, considering that older machines were retired and replaced, and the China ban took about 100 EH/s offline
- We assess most of that capacity remains offline

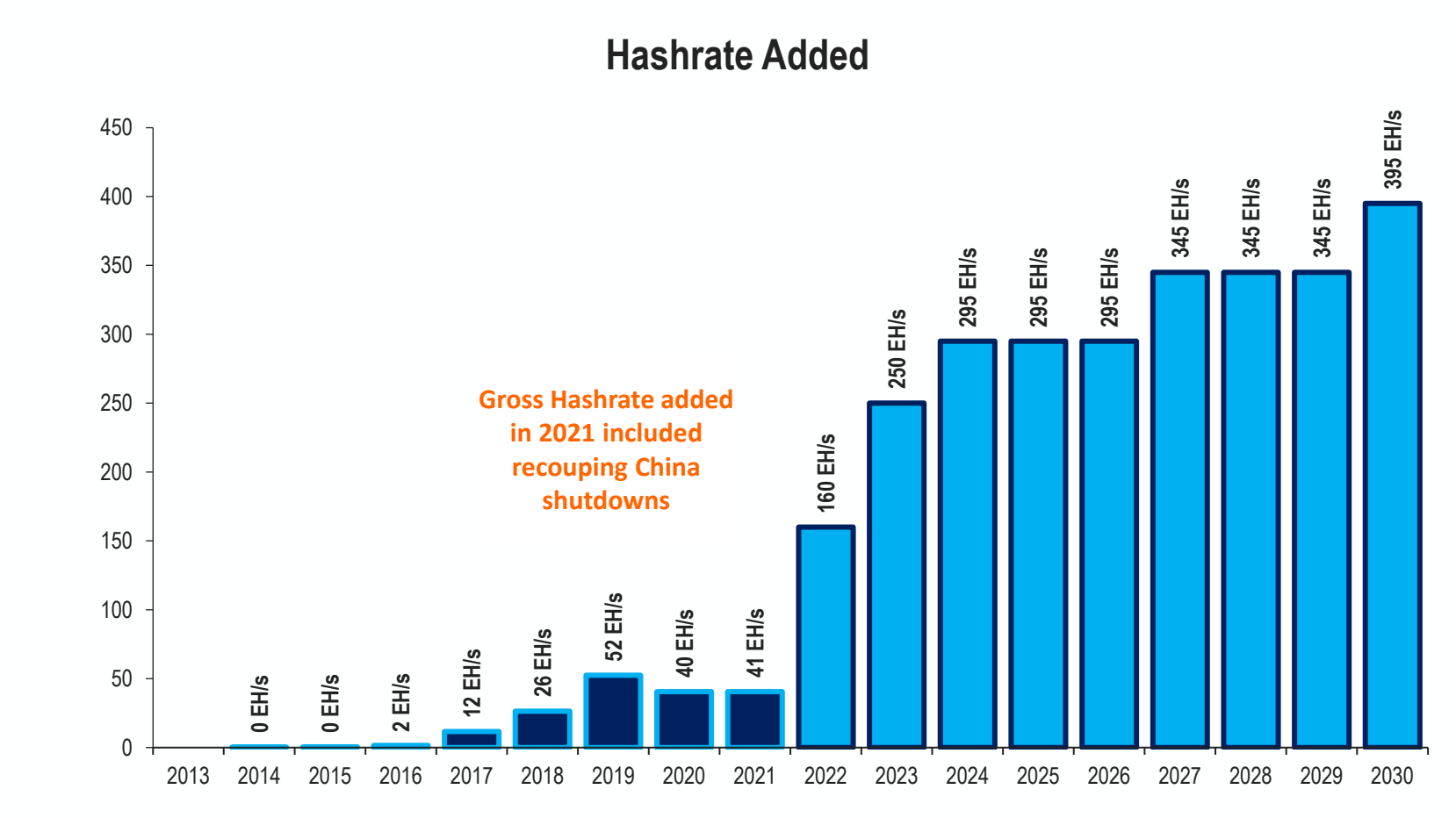


Figure: Hashrate added each year to fill the added power capacity

Source: BitOoda estimates, CoinMetrics, Bloomberg

Network Hashrate:
Could Reach 334EH/s by 2022 YE

- Consistently adding 5GW to the network could get the Bitcoin network to almost 2,900 EH/s by 2030
- This scenario would only come to fruition if BTC price accelerated, thereby preserving margins

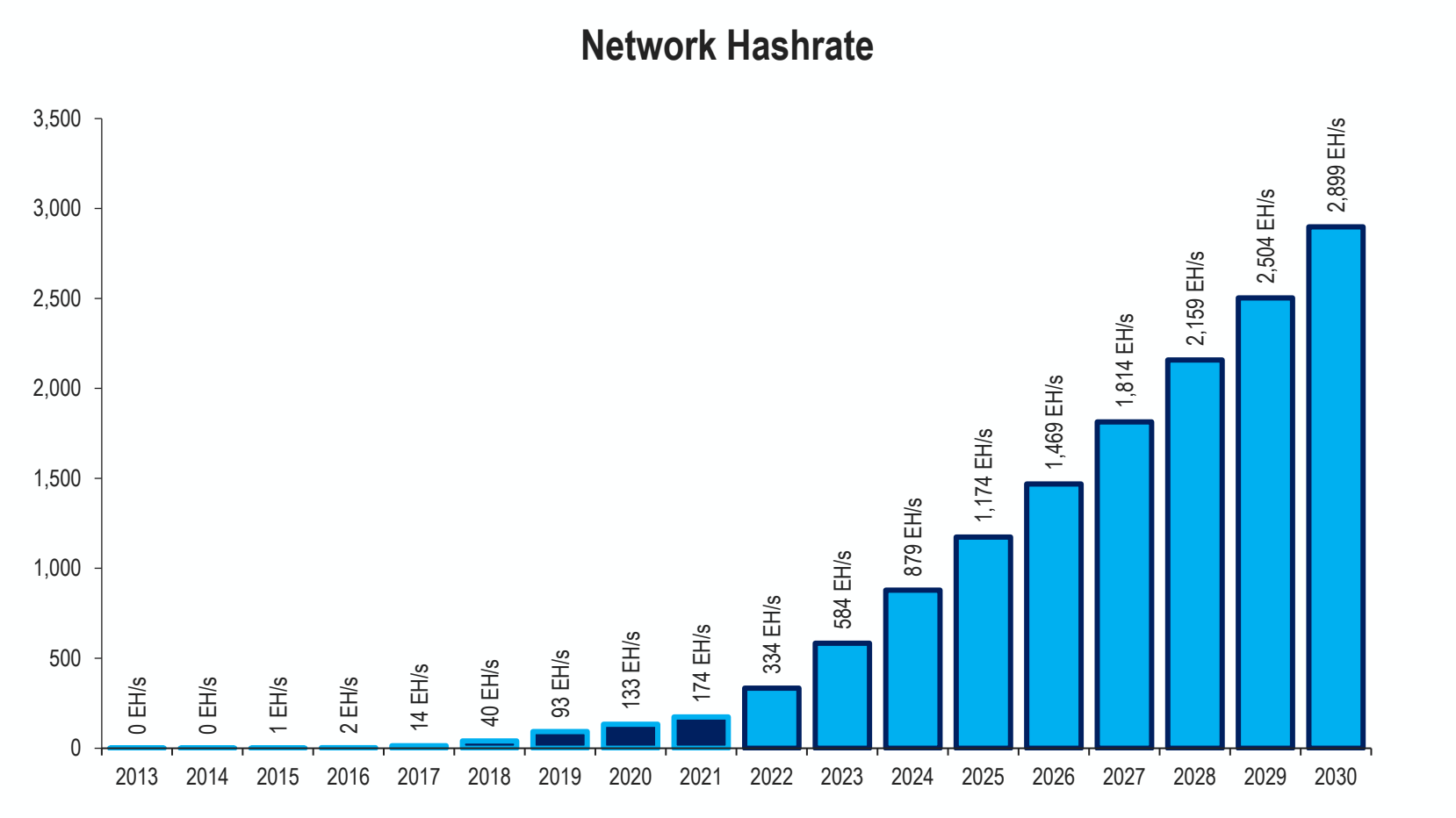


Figure: Network Hashrate at year end, based on power capacity additions

Source: BitOoda estimates, CoinMetrics, Bloomberg

Profit Constraint

How many ASIC rigs can be profitably operated?

Daily Revenue per PH/s
Currently $244 or $10/Hour

- Each PH/s earns ~$10 per hour at current network economics
- S9-class machines deliver 9 PH/s per MW, while S17 and S19-class machines deliver 19 and 26 PH/s per MW, respectively
- Thus, today an S9 makes ~$90 per MWh, while S17s make $190 and S19s make $260
- In this section, we examine these metrics as a function of BTC price and overall network Hashrate, to identify points where remaining S9 and S17-class Hashrate shuts off, and S19 growth gets capped
- **We estimate S9 operating capacity at 8.4EH/s, and 45EH/s for S17s**

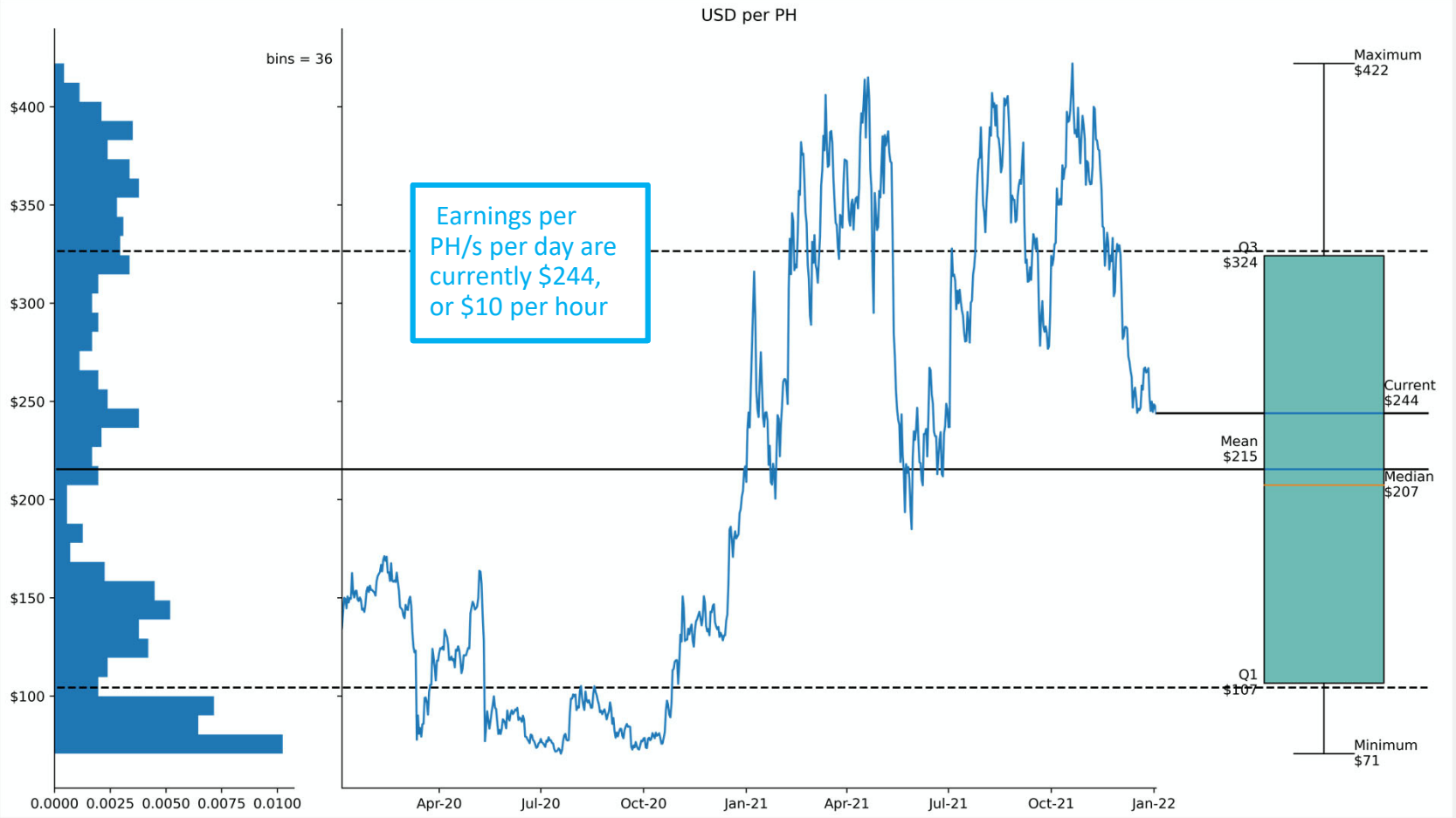


Figure: Bitcoin mining revenue in USD per PH/s over the past two years
As of 1/3/2022

Source: BitOoda, CoinMetrics, Bloomberg

Power Cost Curve

BitOoda Estimates $40/MWh Median Cost

- In July 2020, we published a survey-based cost curve estimate for Bitcoin mining power costs
- The updated cost curve reflects new deals as well as the shutdown of mining in China, which effectively shifted the curve up
- We estimate the current median power cost at $40 / MWh
- This is the raw price of power, not including taxes, fees, or labor / hosting charges
- **Miners will shut down machines if revenue falls below power cost, barring a take-or-pay power purchase agreement**

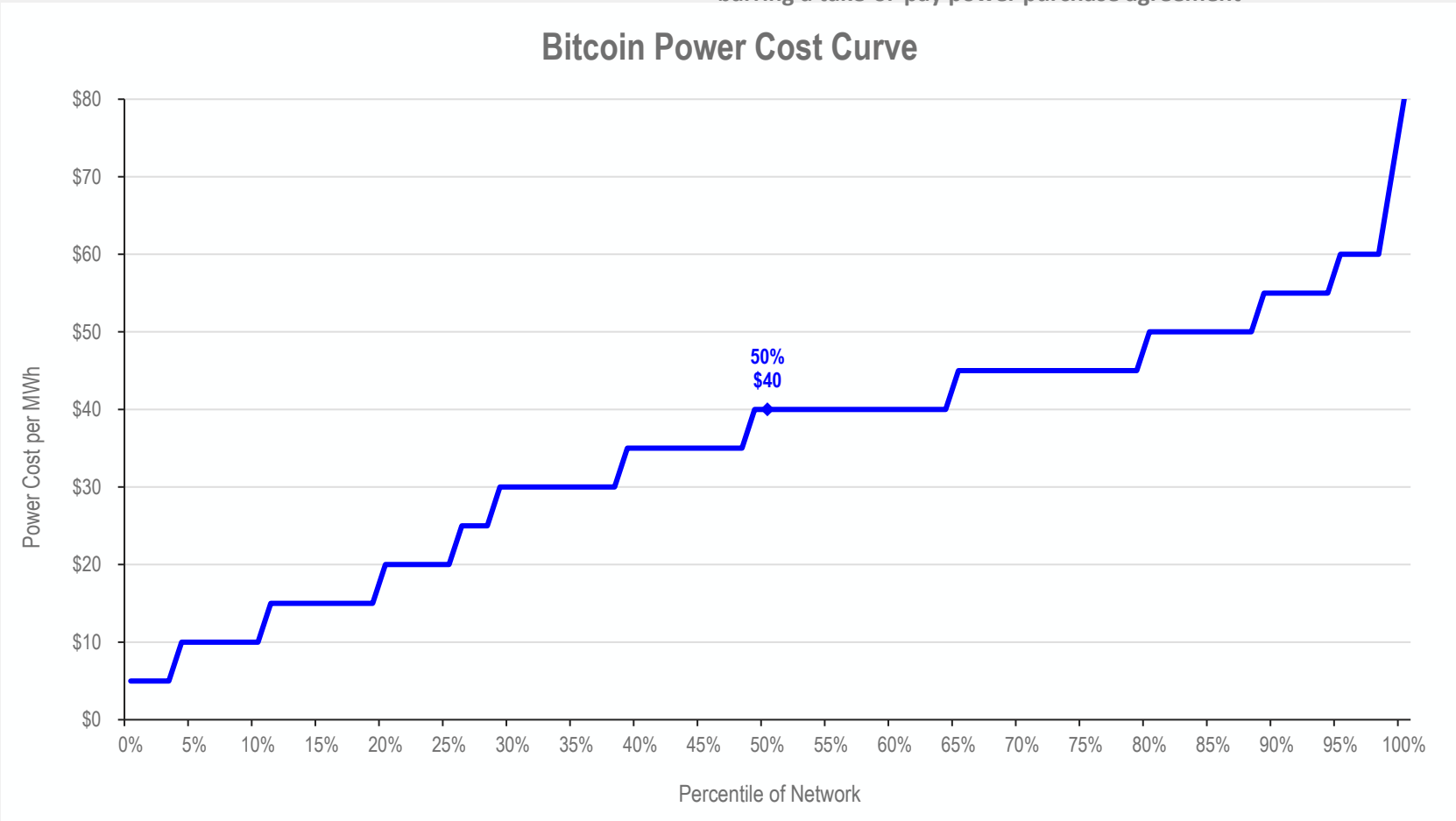


Figure: Power cost curve: Mapping estimated power cost vs. share of network capacity
As of 1/3/2022

Source: BitOoda, CoinMetrics, Bloomberg

S9-Class Shut in Economics
$35,000 Bitcoin at 327 EH/s

- Bitcoin has sold off its highs, but remains above $40,000 as of this writing
- If the price of Bitcoin stayed above $35,000, an S9 would still recover its cost of power at network Hashrate of 325 EH/s at a median power price of $40/MWh
- Most S9s operate at sites that are at or well below the median power price
- If BTC fell below $35,000 as hash climbs, we could see some of the 8.4 EH/s of estimated remaining S9 capacity start to shut down
- This does not include labor and operating costs

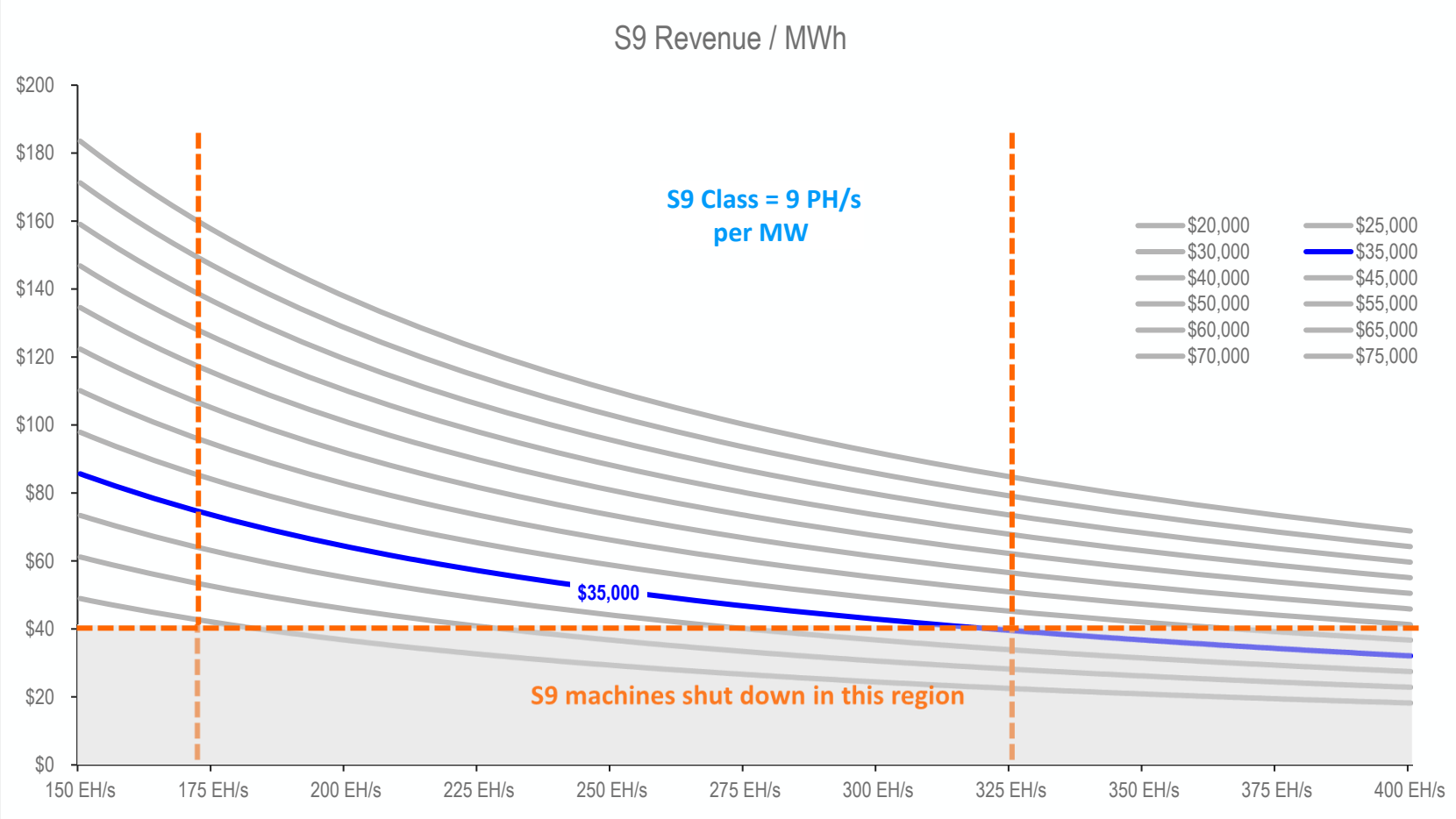


Figure: Revenue per MWh as a function of Hashrate and Bitcoin price at current transaction fees

Source: BitOoda estimates, CoinMetrics, Bloomberg

S17 Class Shut in Economics

Shut in BTC Price Under $20k

- The same analysis puts the 45 EH/s of estimated S17 operating capacity at risk only below a $20,000 Bitcoin price
- This suggests that most of the planned capacity growth this year will be expansion rather than replacement – any upgrades of S17s by one miner will likely result in the S17s finding new operators through the secondary market
- **S19-class and newer devices are profitable well beyond these numbers, both at lower BTC prices and higher network Hashrates**

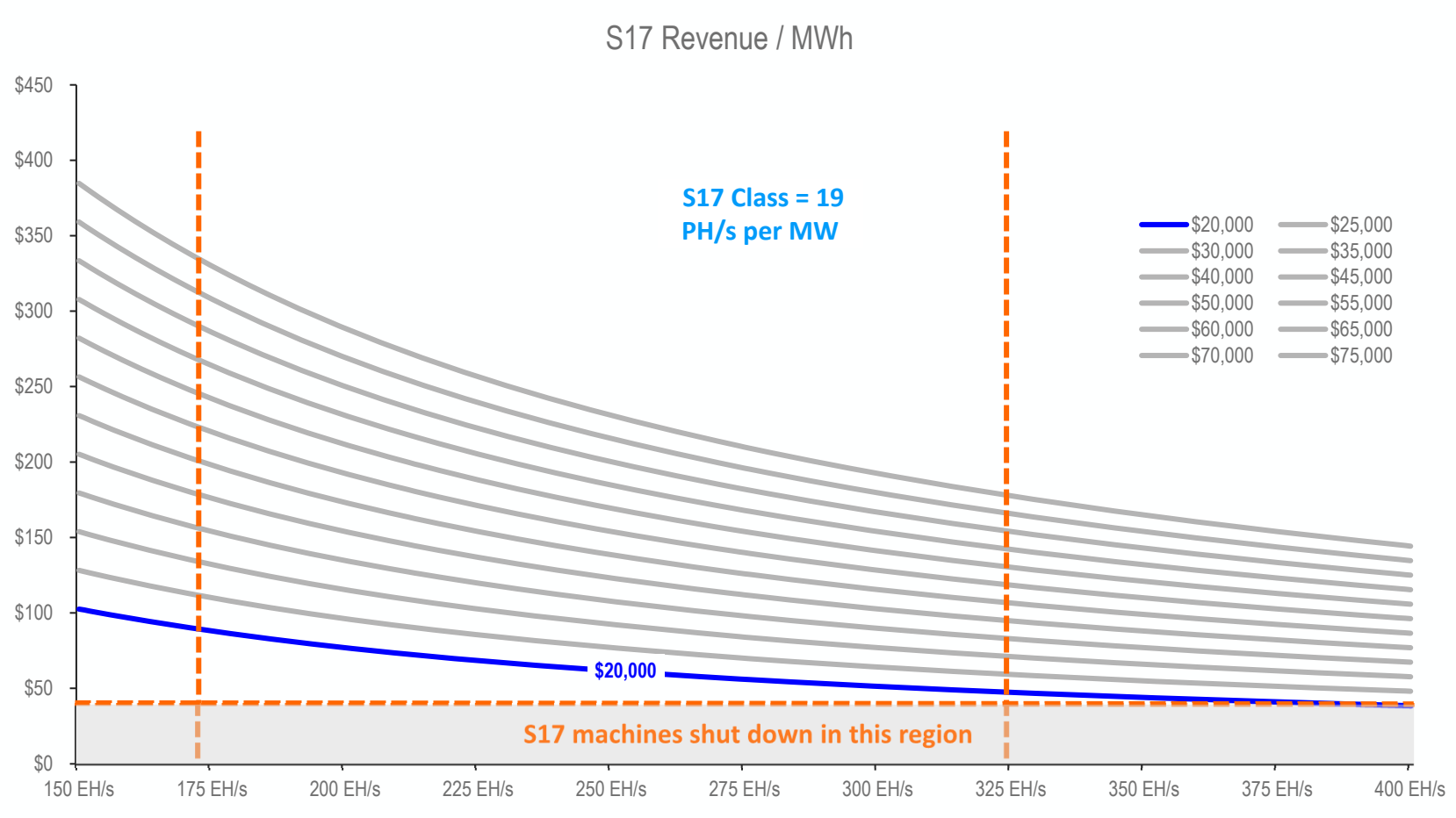


Figure: Revenue per MWh as a function of Hashrate and Bitcoin price at current transaction fees

Source: BitOoda estimates, CoinMetrics, Bloomberg

Miner Economics Sensitivity I:
Daily Revenue / PH/s as a Function of Price and Hashrate

- At the current price and network Hashrate, daily revenue is $245 per PH/s, which is in the 60th percentile historically
- As shown below, our estimated Hashrate for year end 2022 would result in revenue per PH/s per day dropping to $130-160

Bitcoin Price \ Network Hashrate	150 EH/s	175 EH/s	200 EH/s	225 EH/s	250 EH/s	275 EH/s	300 EH/s	325 EH/s	350 EH/s	375 EH/s	400 EH/s	425 EH/s	450 EH/s	475 EH/s	500 EH/s
$25,000	$162	$139	$121	$108	$97	$88	$81	$75	$69	$65	$61	$57	$54	$51	$49
$35,000	226	194	170	151	136	124	113	105	97	91	85	80	75	72	68
$45,000	291	250	218	194	175	159	146	134	125	116	109	103	97	92	87
$55,000	356	305	267	237	214	194	178	164	153	142	133	126	119	112	107
$65,000	421	360	315	280	252	229	210	194	180	168	158	148	140	133	126
$75,000	485	416	364	324	291	265	243	224	208	194	182	171	162	153	146
$85,000	550	471	412	367	330	300	275	254	236	220	206	194	183	174	165
$95,000	615	527	461	410	369	335	307	284	263	246	231	217	205	194	184
$105,000	679	582	510	453	408	371	340	314	291	272	255	240	226	215	204
$115,000	744	638	558	496	446	406	372	343	319	298	279	263	248	235	223
$125,000	809	693	607	539	485	441	404	373	347	324	303	285	270	255	243

Current

2022 YE Est

Figure: Daily revenue per PH/s as a function of Bitcoin Price and Network Hashrate

Source: BitOoda estimates, CoinMetrics

Miner Economics Sensitivity II:
Network Hashrate Implied by Daily Rev./ PH/s & BTC Price

- Here, we show what network Hashrate would be at different BTC prices and at different levels of revenue per PH/s per day
- If the market continues to mean revert, we would expect the daily revenue to drop over time

Bitcoin Price \ $ / PH/s Per Day	$50	$75	$100	$125	$150	$175	$200	$225	$250	$275	$300	$325	$350	$375	$400
$25,000	485 EH/s	324 EH/s	243 EH/s	194 EH/s	162 EH/s	139 EH/s	121 EH/s	108 EH/s	97 EH/s	88 EH/s	81 EH/s	75 EH/s	69 EH/s	65 EH/s	61 EH/s
$35,000	679	453	340	272	226	194	170	151	136	124	113	105	97	91	85
$45,000	874	582	437	349	291	250	218	194	175	159	146	134	125	116	109
$55,000	1068	712	534	427	356	305	267	237	214	194	178	164	153	142	133
$65,000	1262	841	631	505	421	360	315	280	252	229	210	194	180	168	158
$75,000	1456	971	728	582	485	416	364	324	291	265	243	224	208	194	182
$85,000	1650	1100	825	660	550	471	412	367	330	300	275	254	236	220	206
$95,000	1844	1229	922	738	615	527	461	410	369	335	307	284	263	246	231
$105,000	2038	1359	1019	815	679	582	510	453	408	371	340	314	291	272	255
$115,000	2232	1488	1116	893	744	638	558	496	446	406	372	343	319	298	279
$125,000	2426	1618	1213	971	809	693	607	539	485	441	404	373	347	324	303

Current

Figure: Network Hashrate implied at different daily revenue per PH/s and Bitcoin price combinations

Source: BitOoda estimates, CoinMetrics

Miner Economics Sensitivity III:
BTC Price Implied by Daily Revenue and Network Hashrate

- At the current network Hashrate, a $225-250 daily revenue per PH/s equates to a price of $40-44k for BTC
- **However, the same economics at a network Hashrate of 325 EH/s would require a BTC price of $73-81k**

$ / PH/s Per Day	Network Hashrate														
	150 EH/s	175 EH/s	200 EH/s	225 EH/s	250 EH/s	275 EH/s	300 EH/s	325 EH/s	350 EH/s	375 EH/s	400 EH/s	425 EH/s	450 EH/s	475 EH/s	500 EH/s
$50	$7,500	$8,750	$10,000	$11,250	$12,500	$13,750	$15,000	$16,250	$17,500	$18,750	$20,000	$21,250	$22,500	$23,750	$25,000
$75	11,250	13,125	15,000	16,875	18,750	20,625	22,500	24,375	26,250	28,125	30,000	31,875	33,750	35,625	37,500
$100	15,000	17,500	20,000	22,500	25,000	27,500	30,000	32,500	35,000	37,500	40,000	42,500	45,000	47,500	50,000
$125	18,750	21,875	25,000	28,125	31,250	34,375	37,500	40,625	43,750	46,875	50,000	53,125	56,250	59,375	62,500
$150	22,500	26,250	30,000	33,750	37,500	41,250	45,000	48,750	52,500	56,250	60,000	63,750	67,500	71,250	75,000
$175	26,250	30,625	35,000	39,375	43,750	48,125	52,500	56,875	61,250	65,625	70,000	74,375	78,750	83,125	87,500
$200	30,000	35,000	40,000	45,000	50,000	55,000	60,000	65,000	70,000	75,000	80,000	85,000	90,000	95,000	100,000
$225	33,750	39,375	45,000	50,625	56,250	61,875	67,500	73,125	78,750	84,375	90,000	95,625	101,250	106,875	112,500
$250	37,500	43,750	50,000	56,250	62,500	68,750	75,000	81,250	87,500	93,750	100,000	106,250	112,500	118,750	125,000
$275	41,250	48,125	55,000	61,875	68,750	75,625	82,500	89,375	96,250	103,125	110,000	116,875	123,750	130,625	137,500
$300	45,000	52,500	60,000	67,500	75,000	82,500	90,000	97,500	105,000	112,500	120,000	127,500	135,000	142,500	150,000
$325	48,750	56,875	65,000	73,125	81,250	89,375	97,500	105,625	113,750	121,875	130,000	138,125	146,250	154,375	162,500
$350	52,500	61,250	70,000	78,750	87,500	96,250	105,000	113,750	122,500	131,250	140,000	148,750	157,500	166,250	175,000
$375	56,250	65,625	75,000	84,375	93,750	103,125	112,500	121,875	131,250	140,625	150,000	159,375	168,750	178,125	187,500
$400	60,000	70,000	80,000	90,000	100,000	110,000	120,000	130,000	140,000	150,000	160,000	170,000	180,000	190,000	200,000

Current

2022 YE Est

Figure: Bitcoin price implied by daily revenue / PH/s and overall network Hashrate

Source: BitOoda estimates, CoinMetrics

S9-Class Revenue / MWh

$50-60 at YE22 at Current BTC Price

- Based on current prices and where we expect the Hashrate to be by year end 2022, S9-class machines still in operation would earn $50-60 per MWh

Bitcoin Price \ Network Hashrate	150 EH/s	175 EH/s	200 EH/s	225 EH/s	250 EH/s	275 EH/s	300 EH/s	325 EH/s	350 EH/s	375 EH/s	400 EH/s	425 EH/s	450 EH/s	475 EH/s	500 EH/s
$25,000	$60	$52	$45	$40	$36	$33	$30	$28	$26	$24	$23	$21	$20	$19	$18
$35,000	84	72	63	56	51	46	42	39	36	34	32	30	28	27	25
$45,000	108	93	81	72	65	59	54	50	46	43	41	38	36	34	32
$55,000	132	113	99	88	79	72	66	61	57	53	50	47	44	42	40
$65,000	156	134	117	104	94	85	78	72	67	63	59	55	52	49	47
$75,000	181	155	135	120	108	98	90	83	77	72	68	64	60	57	54
$85,000	205	175	153	136	123	112	102	94	88	82	77	72	68	65	61
$95,000	229	196	172	152	137	125	114	106	98	91	86	81	76	72	69
$105,000	253	217	190	169	152	138	126	117	108	101	95	89	84	80	76
$115,000	277	237	208	185	166	151	138	128	119	111	104	98	92	87	83
$125,000	301	258	226	201	181	164	150	139	129	120	113	106	100	95	90

Current

2022 YE Est

Figure: Revenue per MWh for S9 class equipment at different Hashrate and BTC Price

Source: BitOoda estimates, CoinMetrics

S17-Class Revenue / MWh
$120-150 at YE22 at Current BTC Price

- Based on current prices and where we expect the Hashrate to be by year end 2022, S17-class machines would earn $120-150 per MWh

Bitcoin Price \ Network Hashrate	150 EH/s	175 EH/s	200 EH/s	225 EH/s	250 EH/s	275 EH/s	300 EH/s	325 EH/s	350 EH/s	375 EH/s	400 EH/s	425 EH/s	450 EH/s	475 EH/s	500 EH/s
$25,000	$149	$128	$112	$99	$89	$81	$74	$69	$64	$60	$56	$53	$50	$47	$45
$35,000	208	179	156	139	125	114	104	96	89	83	78	74	69	66	63
$45,000	268	230	201	179	161	146	134	124	115	107	100	95	89	85	80
$55,000	328	281	246	218	197	179	164	151	140	131	123	116	109	103	98
$65,000	387	332	290	258	232	211	194	179	166	155	145	137	129	122	116
$75,000	447	383	335	298	268	244	223	206	191	179	167	158	149	141	134
$85,000	506	434	380	337	304	276	253	234	217	202	190	179	169	160	152
$95,000	566	485	424	377	339	309	283	261	242	226	212	200	189	179	170
$105,000	625	536	469	417	375	341	313	289	268	250	234	221	208	197	188
$115,000	685	587	514	457	411	374	342	316	293	274	257	242	228	216	205
$125,000	744	638	558	496	447	406	372	344	319	298	279	263	248	235	223

Current

2022 YE Est

Figure: Revenue per MWh for S17 class equipment at different Hashrate and BTC Price

Source: BitOoda estimates, CoinMetrics

S19-Class Revenue / MWh
$145-180 at YE22 at Current BTC Price

- Based on current prices and where we expect the Hashrate to be by year end 2022, S19-class machines would earn $145-180 per MWh

Bitcoin Price \ Network Hashrate	150 EH/s	175 EH/s	200 EH/s	225 EH/s	250 EH/s	275 EH/s	300 EH/s	325 EH/s	350 EH/s	375 EH/s	400 EH/s	425 EH/s	450 EH/s	475 EH/s	500 EH/s
$25,000	$175	$150	$131	$116	$105	$95	$87	$81	$75	$70	$66	$62	$58	$55	$52
$35,000	245	210	183	163	147	133	122	113	105	98	92	86	82	77	73
$45,000	314	270	236	210	189	172	157	145	135	126	118	111	105	99	94
$55,000	384	329	288	256	231	210	192	177	165	154	144	136	128	121	115
$65,000	454	389	341	303	273	248	227	210	195	182	170	160	151	143	136
$75,000	524	449	393	349	314	286	262	242	225	210	197	185	175	166	157
$85,000	594	509	446	396	356	324	297	274	255	238	223	210	198	188	178
$95,000	664	569	498	443	398	362	332	306	285	266	249	234	221	210	199
$105,000	734	629	550	489	440	400	367	339	314	294	275	259	245	232	220
$115,000	804	689	603	536	482	438	402	371	344	321	301	284	268	254	241
$125,000	874	749	655	582	524	476	437	403	374	349	328	308	291	276	262

Current

2022 YE Est

Figure: Revenue per MWh for S19 class equipment at different Hashrate and BTC Price

Source: BitOoda estimates, CoinMetrics

S19XP Revenue / MWh

$190-240 at YE22 at Current BTC Price

- Based on current prices and where we expect the Hashrate to be by year end 2022, S19XP machines would earn $190-240 per MWh

Bitcoin Price \ Network Hashrate	150 EH/s	175 EH/s	200 EH/s	225 EH/s	250 EH/s	275 EH/s	300 EH/s	325 EH/s	350 EH/s	375 EH/s	400 EH/s	425 EH/s	450 EH/s	475 EH/s	500 EH/s
$25,000	$233	$200	$175	$155	$140	$127	$117	$108	$100	$93	$87	$82	$78	$74	$70
$35,000	326	280	245	218	196	178	163	151	140	131	122	115	109	103	98
$45,000	420	360	315	280	252	229	210	194	180	168	157	148	140	133	126
$55,000	513	440	385	342	308	280	256	237	220	205	192	181	171	162	154
$65,000	606	520	455	404	364	331	303	280	260	242	227	214	202	191	182
$75,000	699	600	525	466	420	382	350	323	300	280	262	247	233	221	210
$85,000	793	679	595	528	476	432	396	366	340	317	297	280	264	250	238
$95,000	886	759	664	591	532	483	443	409	380	354	332	313	295	280	266
$105,000	979	839	734	653	588	534	490	452	420	392	367	346	326	309	294
$115,000	1,072	919	804	715	643	585	536	495	460	429	402	379	357	339	322
$125,000	1,166	999	874	777	699	636	583	538	500	466	437	411	389	368	350

Current

2022 YE Est

Figure: Revenue per MWh for S19XP equipment at different Hashrate and BTC Price

Source: BitOoda estimates, CoinMetrics

S19-Class Sets Profit Constraint:
Network Could Support 400EH/s even at $20k BTC

- A BTC price of $20k would still keep all S19-class or later rigs operational even up to 400EH/s per second network Hashrate
- **While such a low price would constrain capital flows and hamper further growth, the bulk of the purchases needed to get to such a number have already been committed to**

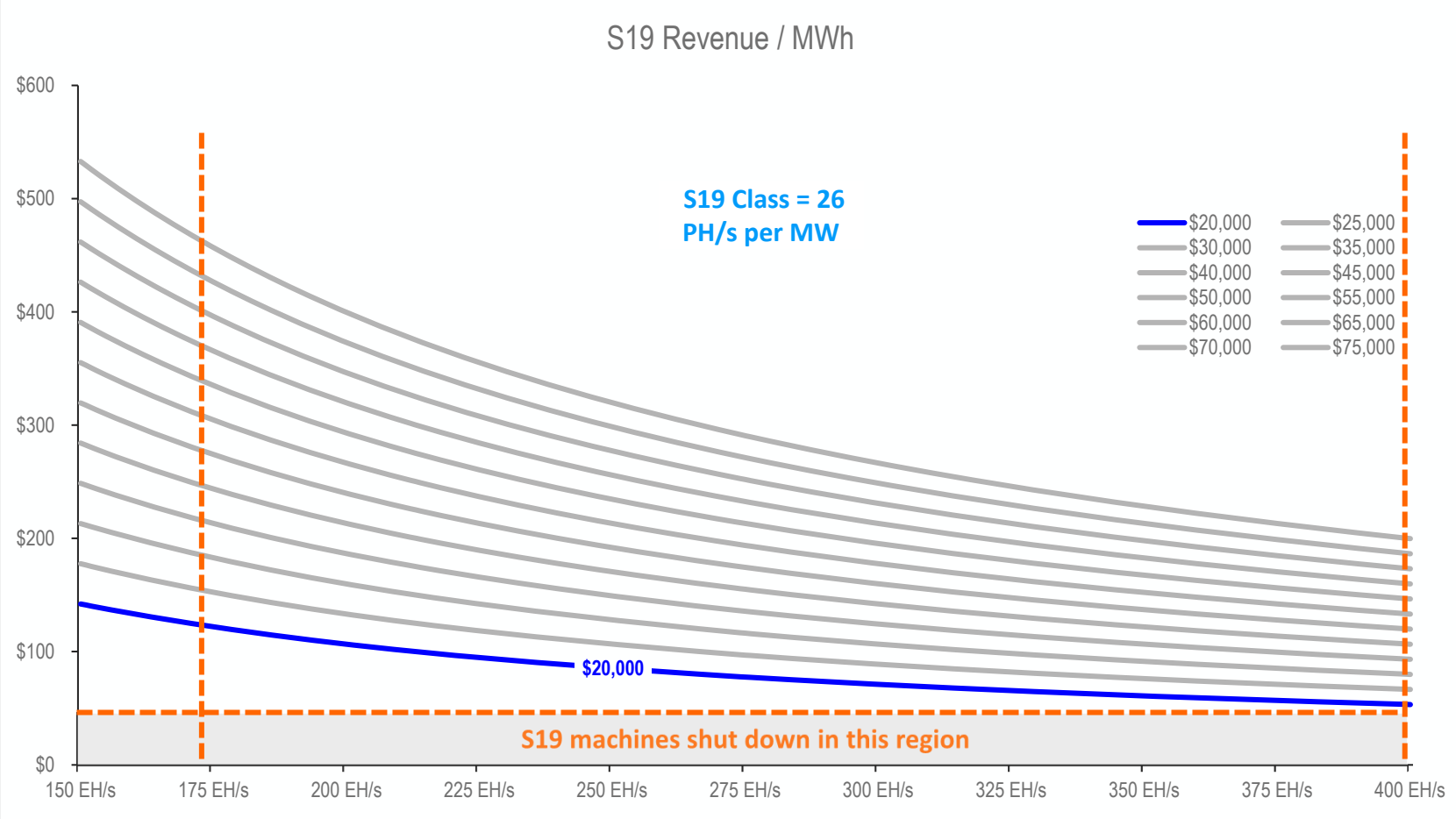


Figure: Revenue per MWh as a function of Hashrate and Bitcoin price at current transaction fees

Source: BitOoda estimates, CoinMetrics, Bloomberg

Hashrate Estimate

Official BitOoda Hashrate Estimate:
327 EH/s by Year End 2022

BitOoda Hashrate Estimate
327 EH/s by Year End 2022

- We assess that the most likely scenario is 327 EH/s by year end 2022
- However, significant price movements, regulatory or environmental shifts, supply chain disruptions and capital market conditions could affect the realized Hashrate
- It is an open question whether all rig and site / power commitments are fully funded, or whether capital could dry up in a sustained Bitcoin bear market, which could lead to miners defaulting and unable to make balance payments and accept delivery

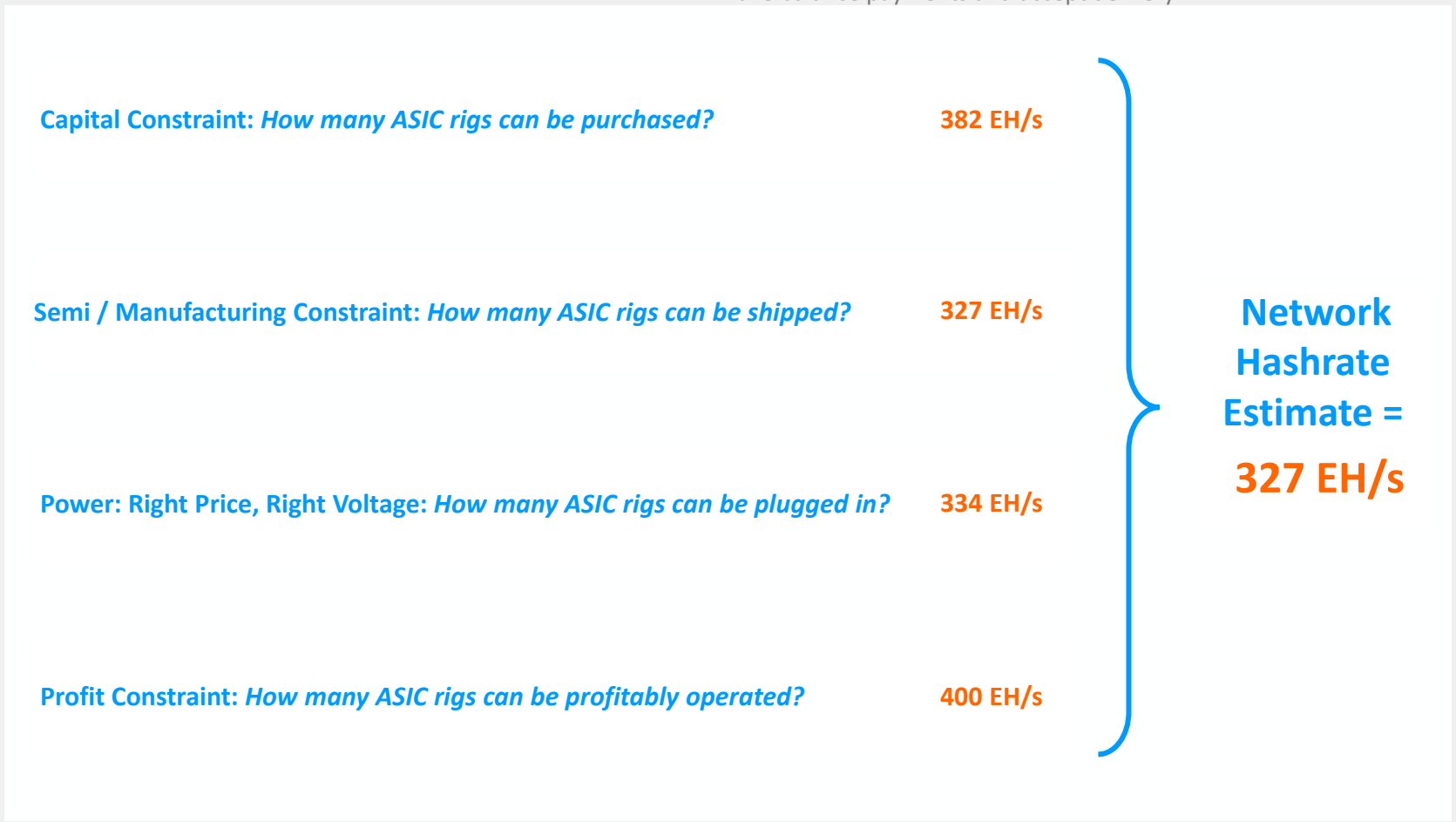


Figure: BitOoda Hashrate estimates by constraint as of 1/3/2022

Source: BitOoda estimates, CoinMetrics, Bloomberg

New 2022 Hash Estimate:
~327 EH/s by Year End

- Our projections call for a target Hashrate of ~327EH/s by year end 2022
- This is slightly below our most recent prior estimate of 334EH/s and represents 88% year-on-year growth vs. Dec 2021
- We expect power infrastructure to be the gating factor in mining expansion earlier in the year, but to start easing later in the year
- **The Hashrate growth pace averages 12.8 EH/s per month, but we suspect deployments will be somewhat back end loaded: 51EH/s in Q4 2022 vs. 18-20 EH/s in Q1 2022**

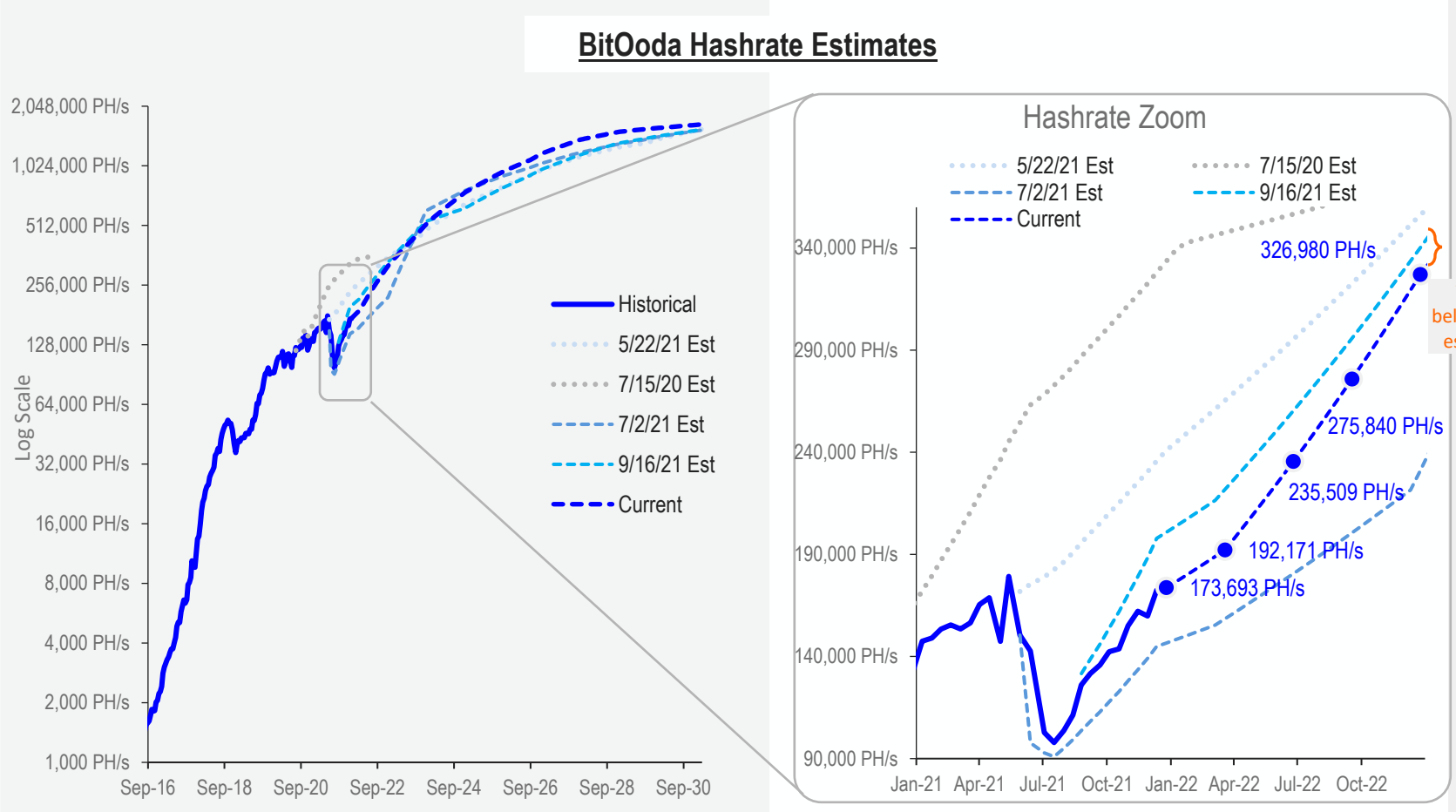


Figure: Historical and Estimated Target Hashrate 2017-2030
Historical as of 12/25/21; Estimates as of current, 9/16/21, 7/2/21, 5/22/21, and 7/15/20

Source: BitOoda estimates, CoinMetrics

Monthly Hashrate Estimates

- For easy reference, we show the month-by-month ending target Hashrate estimate for the Bitcoin network
- These are the same numbers as represented in the chart on the preceding page

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	111 EH/s	111 EH/s	100 EH/s	114 EH/s	108 EH/s	113 EH/s	121 EH/s	126 EH/s	138 EH/s	143 EH/s	126 EH/s	133 EH/s
2021	149	155	156	169	179	143	98	126	136	144	160	174
2022	180	186	192	204	223	236	249	262	276	290	312	327
2023	340	353	366	380	401	415	430	445	463	490	509	529
2024	545	561	577	602	619	636	654	672	699	718	737	756
2025	771	786	801	824	839	855	871	887	911	928	944	961
2026	976	998	1,012	1,027	1,042	1,058	1,073	1,088	1,117	1,138	1,160	1,182
2027	1,197	1,220	1,236	1,251	1,267	1,283	1,299	1,323	1,339	1,355	1,371	1,387
2028	1,397	1,412	1,422	1,432	1,442	1,452	1,461	1,476	1,486	1,496	1,506	1,517
2029	1,527	1,532	1,538	1,543	1,548	1,554	1,562	1,567	1,572	1,577	1,581	1,586
2030	1,593	1,597	1,602	1,606	1,611	1,615	1,622	1,627	1,631	1,636	1,640	1,647

Figure: Month-end target Hashrate estimates for the forecast period

Source: BitOoda estimates, CoinMetrics, Bloomberg

Historical USD / PH/s: Implied Future BTC Prices

- Over the past two years, revenue per PH/s has ranged from $71 to $422 per day, as seen in the box plot below left
- Based on our estimated forward network Hashrate and daily BTC mined (including Tx fees), we estimate the price Bitcoin would have to be in order to match the historical economics of mining per PH/s
- On our estimated 327 EH/s, BTC would need to be at $87k by YE 2022, and $684k by YE 2030, to earn the same $244 a miner earns per PH/s per day today

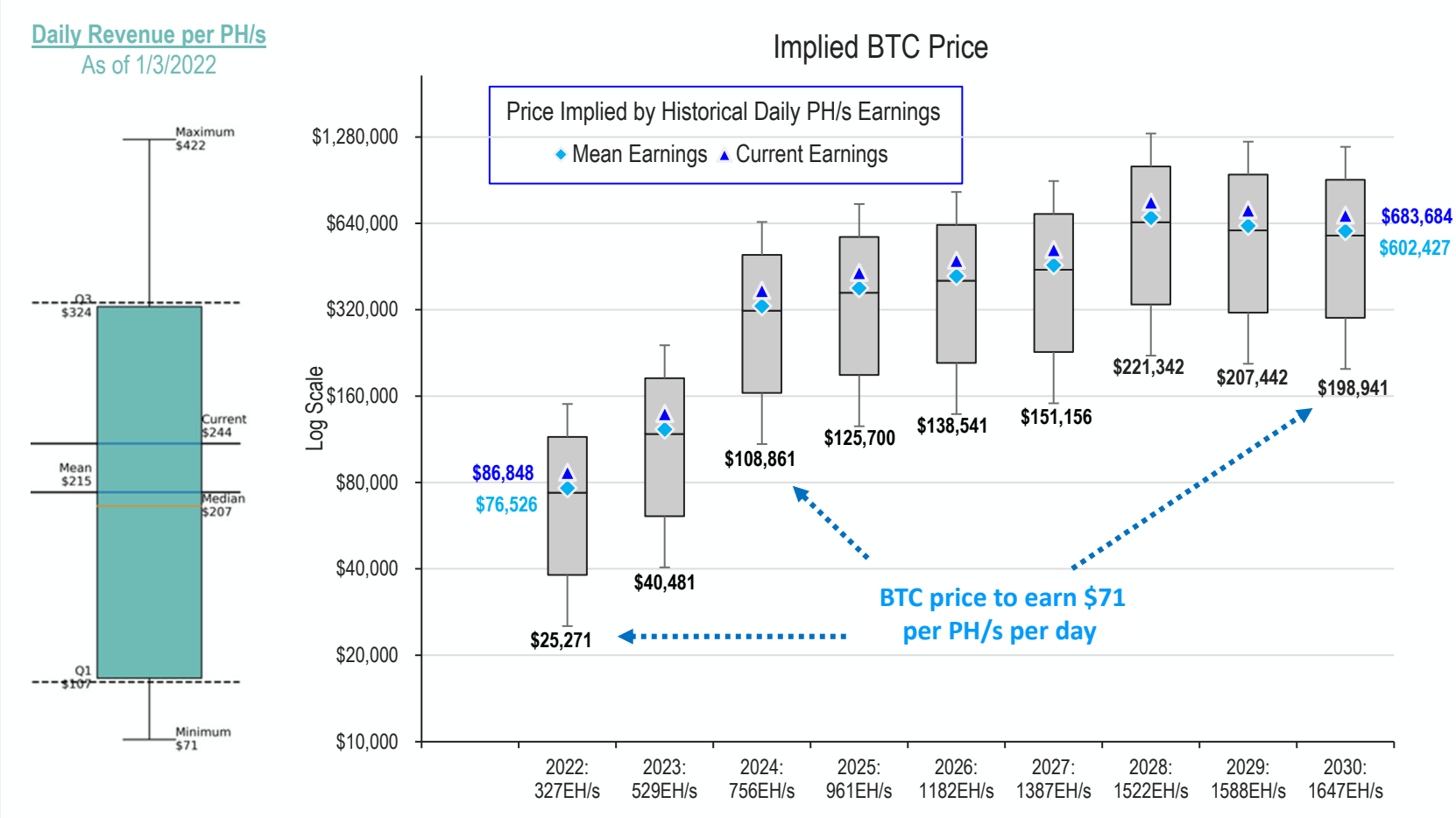


Figure: Implied price range of Bitcoin to match the trailing 2-year range of daily earnings per PH/s, at the higher future network Hashrate

Source: BitOoda, CoinMetrics, Bloomberg

Historical USD / PH/s: Implied Future BTC Prices - Table

- We show below the price BTC would need to be in the future to achieve the same daily revenue ranges per PH/s at future hashrates, as achieved in recent history

				Daily USD Rev / PH/s, Current Range						
Year End	Hashrate	Daily BTC	BTC / PH/s / Day	Minimum $71	25th Percentile $107	Median $207	Mean $215	75th Percentile $324	Current $244	Max $422
2022	327 EH/s	918.65	0.0028	$25,271	$38,085	$73,679	$76,526	$115,323	$86,848	$150,205
2023	529 EH/s	927.47	0.0018	$40,481	$61,006	$118,022	$122,583	$184,730	$139,117	$240,605
2024	756 EH/s	493.13	0.0007	$108,861	$164,058	$317,384	$329,650	$496,774	$374,114	$647,033
2025	961 EH/s	543.00	0.0006	$125,700	$189,435	$366,477	$380,640	$573,616	$431,982	$747,117
2026	1,182 EH/s	605.63	0.0005	$138,541	$208,787	$403,914	$419,525	$632,214	$476,112	$823,439
2027	1,387 EH/s	651.58	0.0005	$151,156	$227,798	$440,694	$457,726	$689,782	$519,465	$898,420
2028	1,522 EH/s	488.06	0.0003	$221,342	$333,572	$645,321	$670,261	$1,010,068	$760,668	$1,315,582
2029	1,588 EH/s	543.68	0.0003	$207,442	$312,624	$604,796	$628,170	$946,637	$712,900	$1,232,966
2030	1,647 EH/s	587.80	0.0004	$198,941	$299,812	$580,011	$602,427	$907,843	$683,684	$1,182,438

Figure: Implied price range of Bitcoin to match the current range of daily earnings per PH/s, at the higher future network Hashrate

Source: BitOoda, CoinMetrics, Bloomberg

Profitability Analytics

Capex recovery, revenue and cost analysis

Investment Payback
Days to Recover Capex

- We examine the days needed to recover capex, after power and labor costs
- Investment recovery periods could really stretch out as equipment costs rise
- This is especially a concern if rigs are procured at current prices and revenue per day reverted to the mean / median levels of recent history
- 500-600 day paybacks, excluding infrastructure / container / ancillary capex, could prove challenging

	Daily USD Rev / PH/s, Current Range						
	Minimum	25th Percentile	Median	Mean	75th Percentile	Current	Max
Capital Cost / TH/s	$71	$107	$207	$215	$324	$244	$422
$10	364 Days	158 Days	61 Days	58 Days	36 Days	50 Days	26 Days
$20	728	315	122	117	71	100	53
$30	1092	473	184	175	107	150	79
$40	1455	630	245	233	143	200	106
$50	1819	788	306	292	178	249	132
$60	2183	945	367	350	214	299	159
$70	2547	1103	428	408	250	349	185
$80	2911	1260	489	467	285	399	211
$90	3275	1418	551	525	321	449	238
$100	3638	1575	612	583	357	499	264
$110	4002	1733	673	641	392	549	291
$120	4366	1890	734	700	428	599	317
$130	4730	2048	795	758	463	648	343
$140	5094	2205	856	816	499	698	370
$150	5458	2363	918	875	535	748	396

Capex costs of $80-100 per TH/s could result in prohibitive payback periods if the revenue mean reverts

Figure: Days to recover rig investment as a function of revenue per PH/s per day, assuming $40/MWh median power cost, PUE of 1.12, and 34W / TH/s efficiency and $7/MWh labor cost

Source: BitOoda, CoinMetrics, Bloomberg

MWh per BTC Mined
Using Latest-Gen Rigs

- The price of Bitcoin affects the viability of operating older-gen rigs
- Theoretical efficiencies show the relationship of power consumption to network Hashrate

		Power consumption to produce 1 Bitcoin, based on device power efficiency (Watts / TH/s)										
Year End		100 W	80 W	50 W	40 W	35 W	30 W	25 W	20 W	15 W	10 W	5 W
2022	327 EH/s	957 MWh	765 MWh	478 MWh	383 MWh	335 MWh	287 MWh	239 MWh	191 MWh	144 MWh	96 MWh	48 MWh
2023	529 EH/s	1533	1226	766	613	536	460	383	307	230	153	77
2024	756 EH/s	4121	3297	2061	1649	1442	1236	1030	824	618	412	206
2025	961 EH/s	4759	3807	2379	1904	1666	1428	1190	952	714	476	238
2026	1,182 EH/s	5245	4196	2623	2098	1836	1574	1311	1049	787	525	262
2027	1,387 EH/s	5723	4578	2861	2289	2003	1717	1431	1145	858	572	286
2028	1,522 EH/s	8380	6704	4190	3352	2933	2514	2095	1676	1257	838	419
2029	1,588 EH/s	7854	6283	3927	3141	2749	2356	1963	1571	1178	785	393
2030	1,647 EH/s	7532	6025	3766	3013	2636	2260	1883	1506	1130	753	377

Figure: Power consumption per Bitcoin mined, by theoretical power efficiency, in MWh
PUE (Power Usage Effectiveness) assumed at 1.12

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 100W / TH/s Rigs

- By YE 2022, it should take $6,697 in labor and $9,568 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 100W machines would be $6,697 + 9,568 x 2 = $25,923

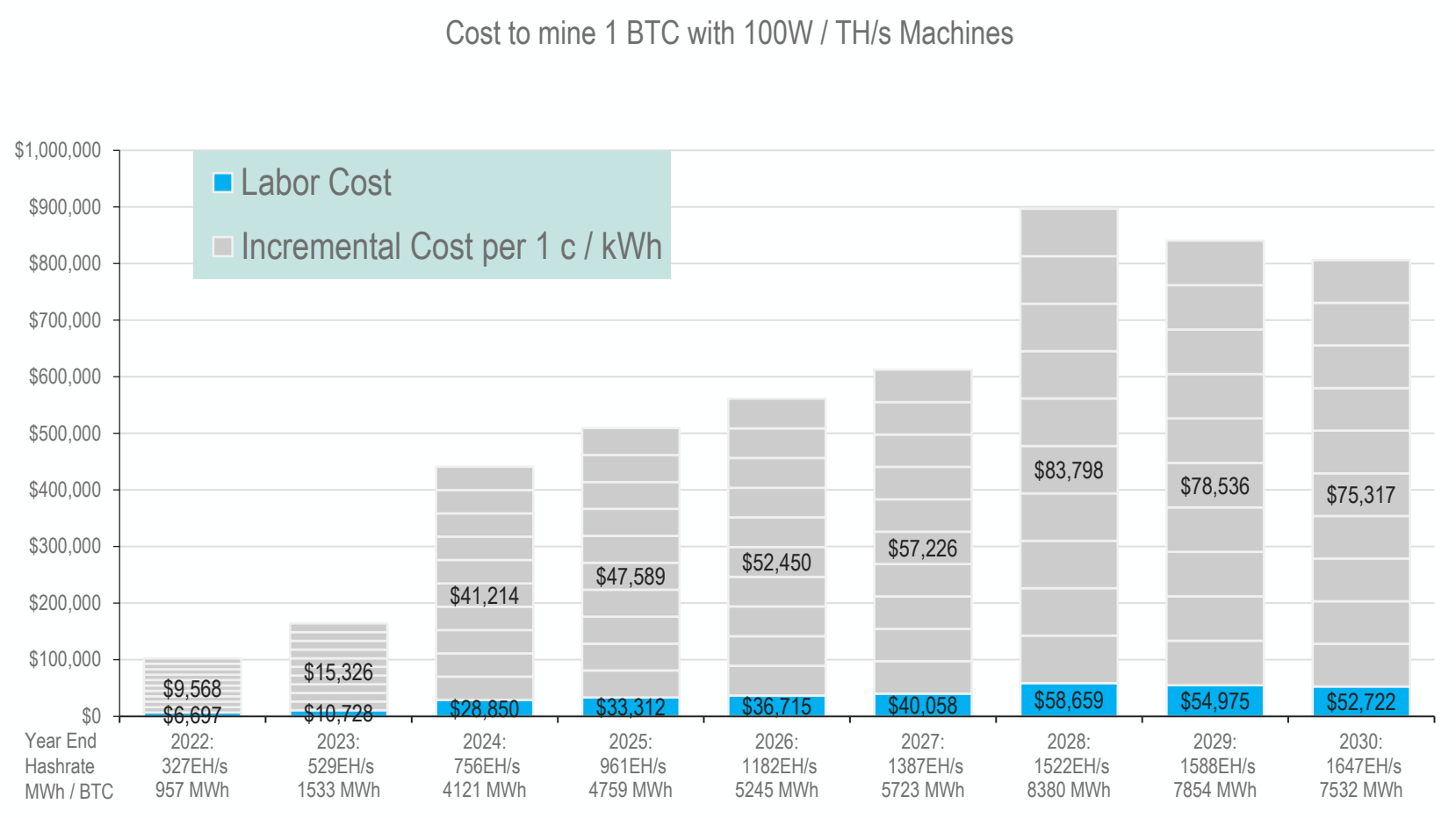


Figure: Cost to mine 1 Bitcoin using a 100 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 80W / TH/s Rigs

- By YE 2022, it should take $5,358 in labor and $7,654 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 80W machines would be $5,358 + 7,654 x 2 = $20,666

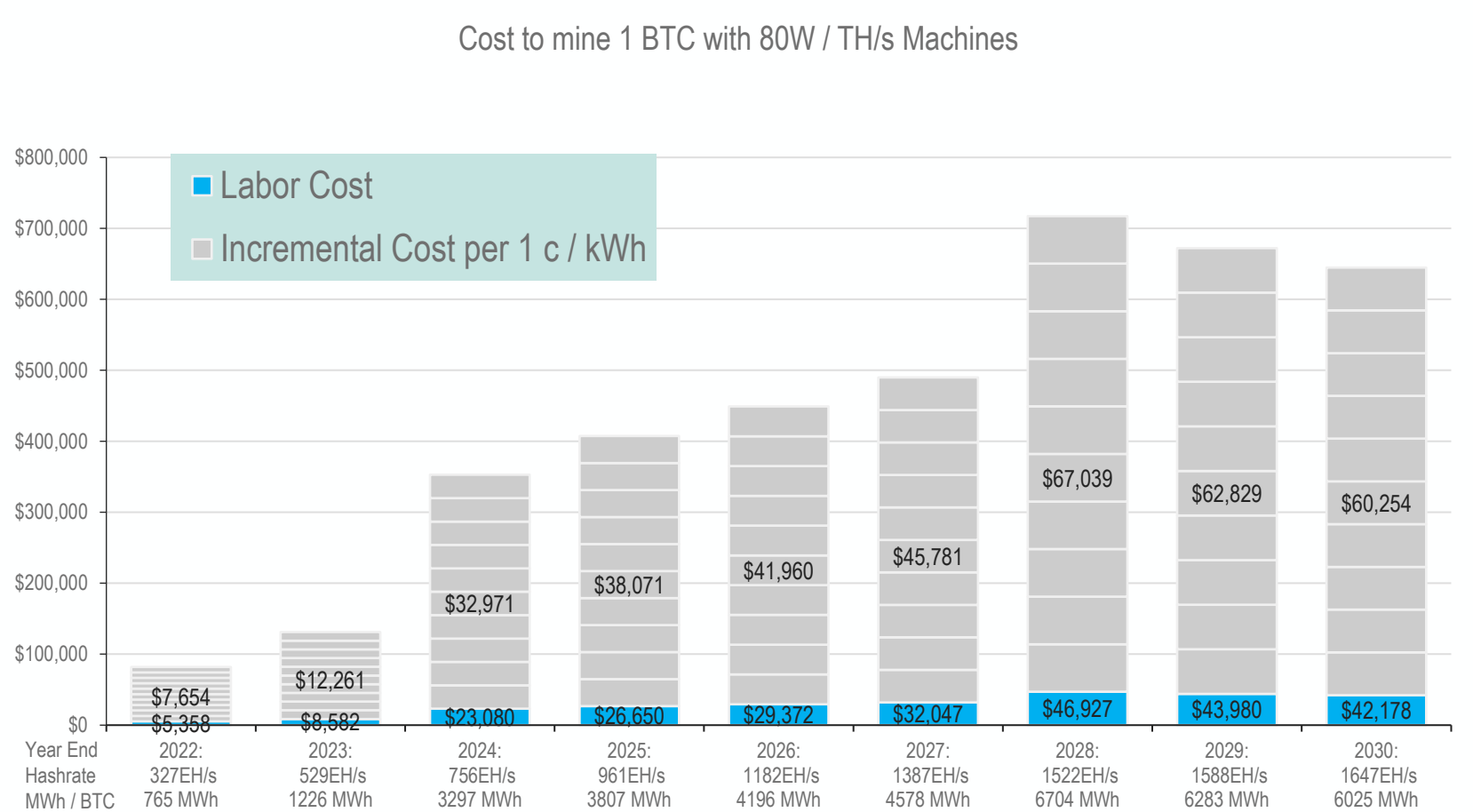


Figure: Cost to mine 1 Bitcoin using a 80 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 50W / TH/s Rigs

- By YE 2022, it should take $3,349 in labor and $4,784 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 50W machines would be $3,349 + 4,784 x 2 = $12,917

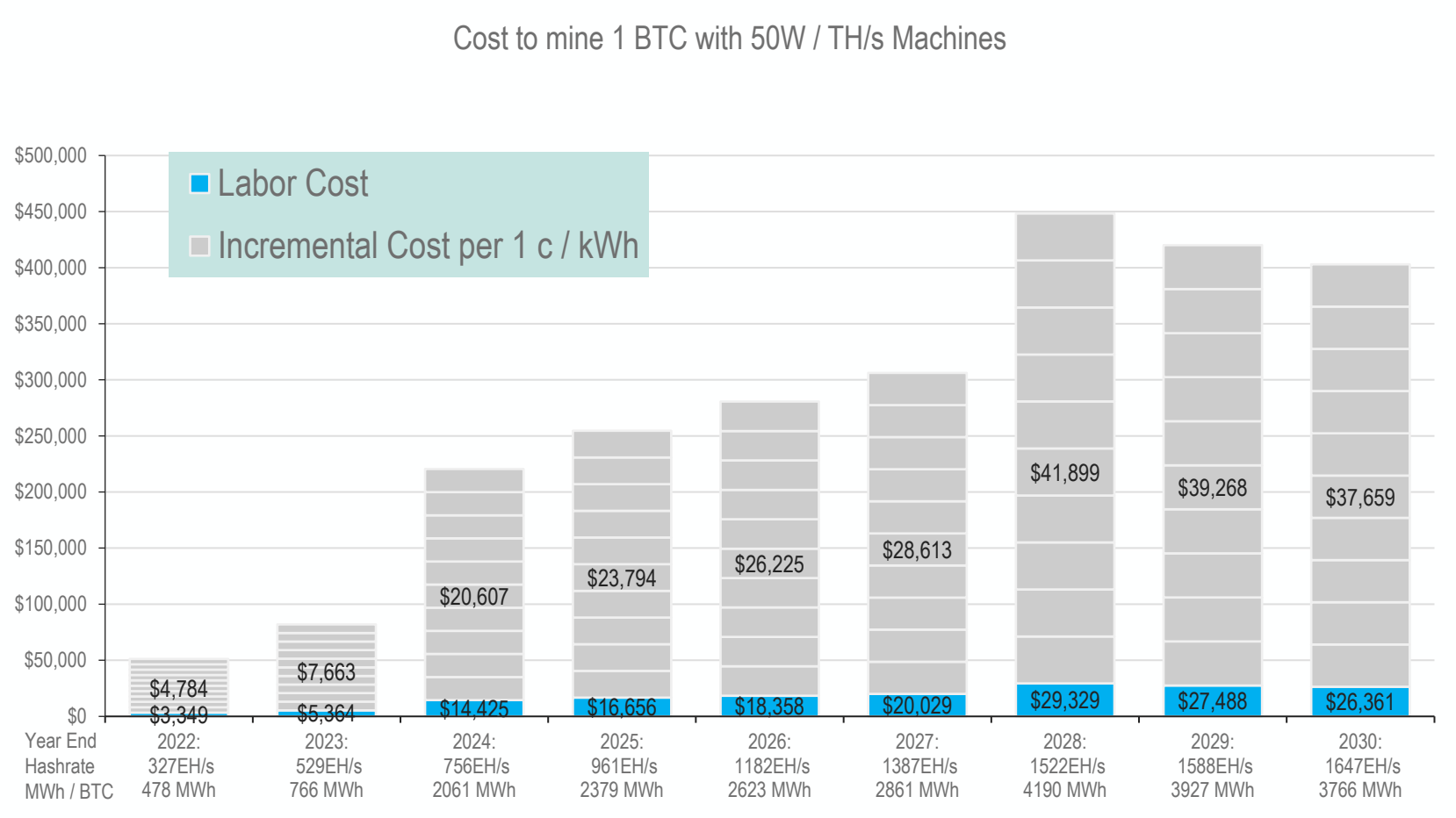


Figure: Cost to mine 1 Bitcoin using a 50 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 40W / TH/s Rigs

- By YE 2022, it should take $2,679 in labor and $3,827 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 40W machines would be $2,679 + 3,827 x 2 = $10,333

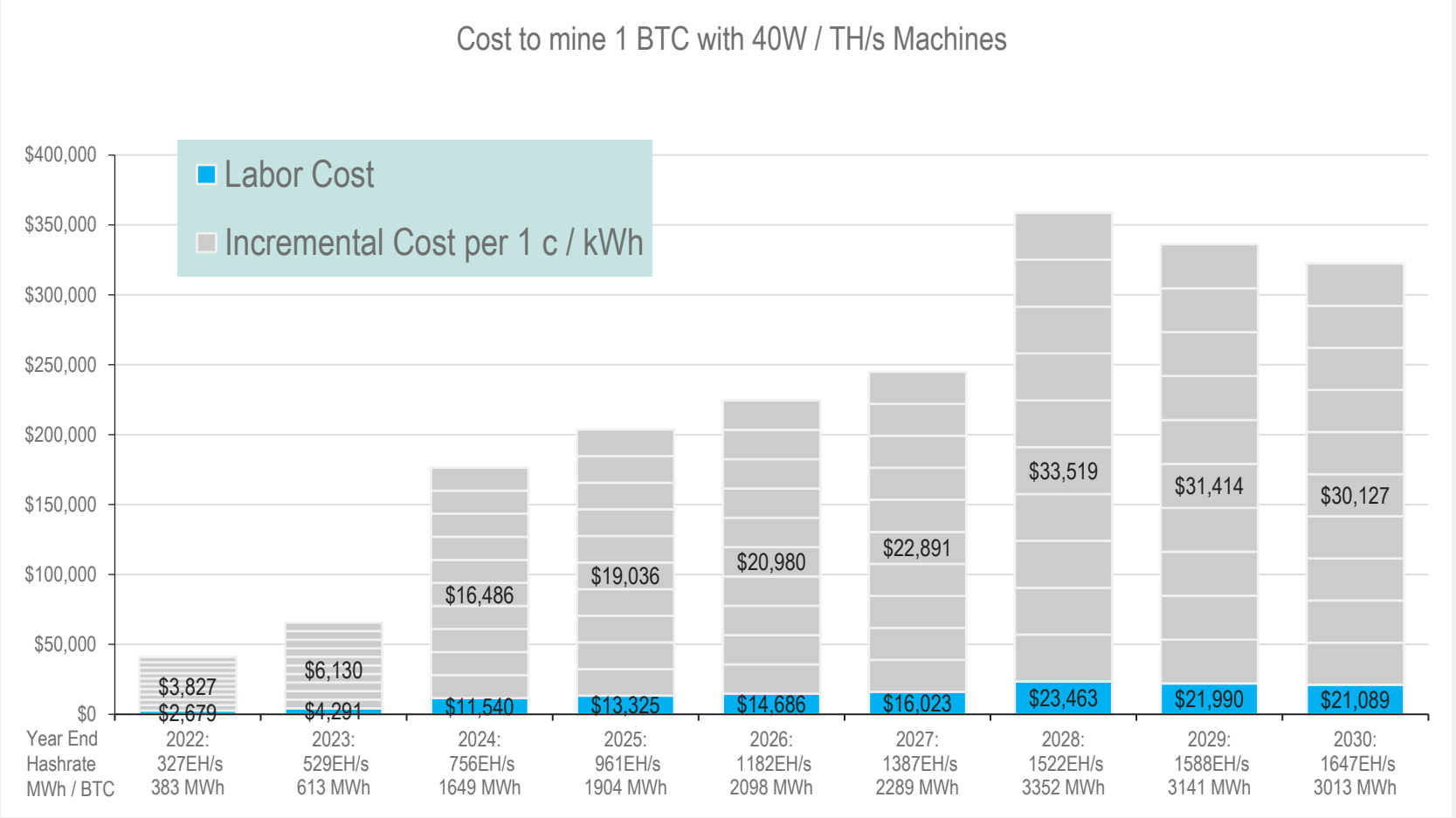


Figure: Cost to mine 1 Bitcoin using a 40 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 35W / TH/s Rigs

- By YE 2022, it should take $2,344 in labor and $3,349 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 35W machines would be $2,344 + 3,349 x 2 = $9,042

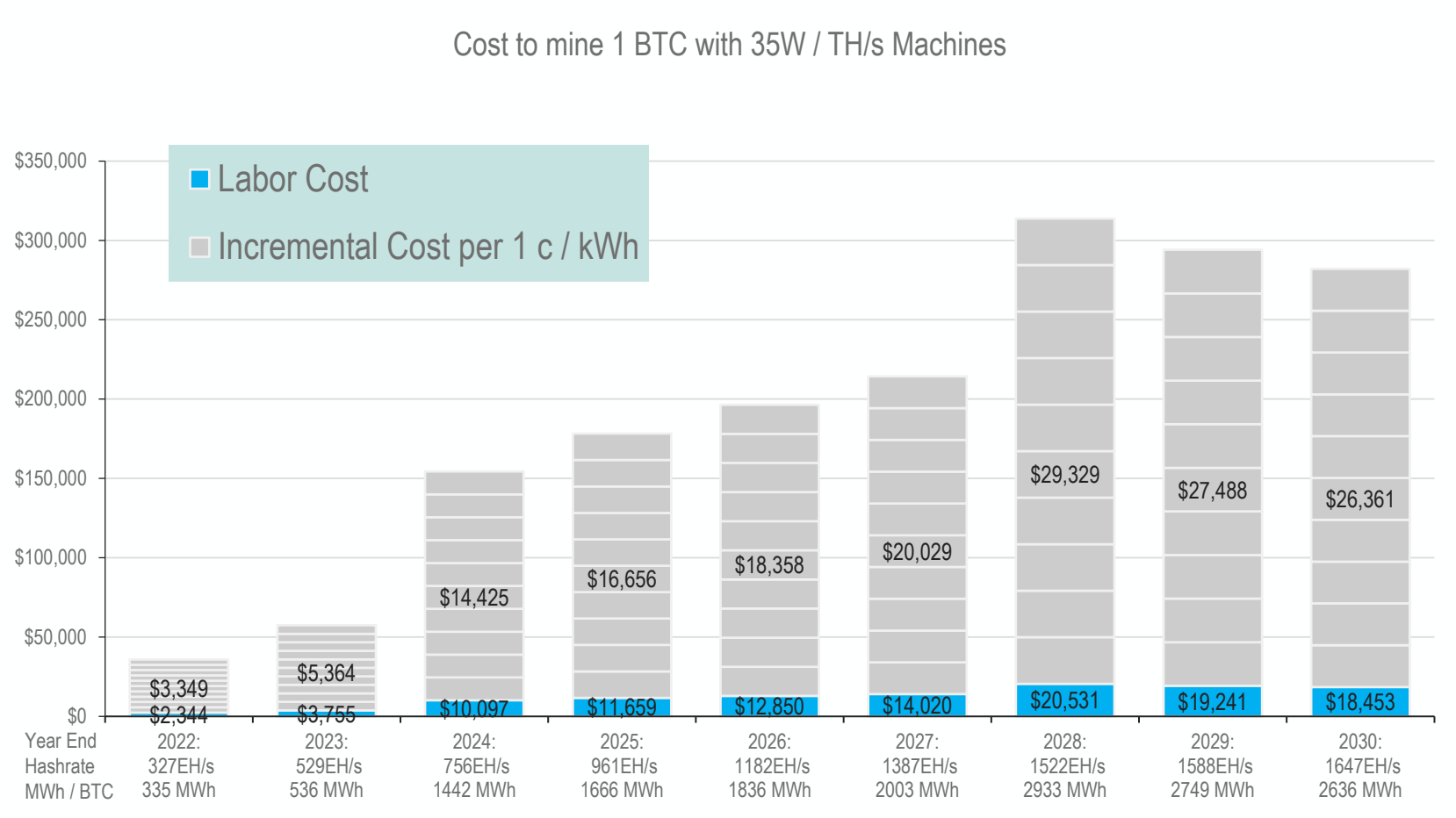


Figure: Cost to mine 1 Bitcoin using a 35 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 30W / TH/s Rigs

- By YE 2022, it should take $2,009 in labor and $2,870 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 30W machines would be $2,009 + 2,870 x 2 = $7,749

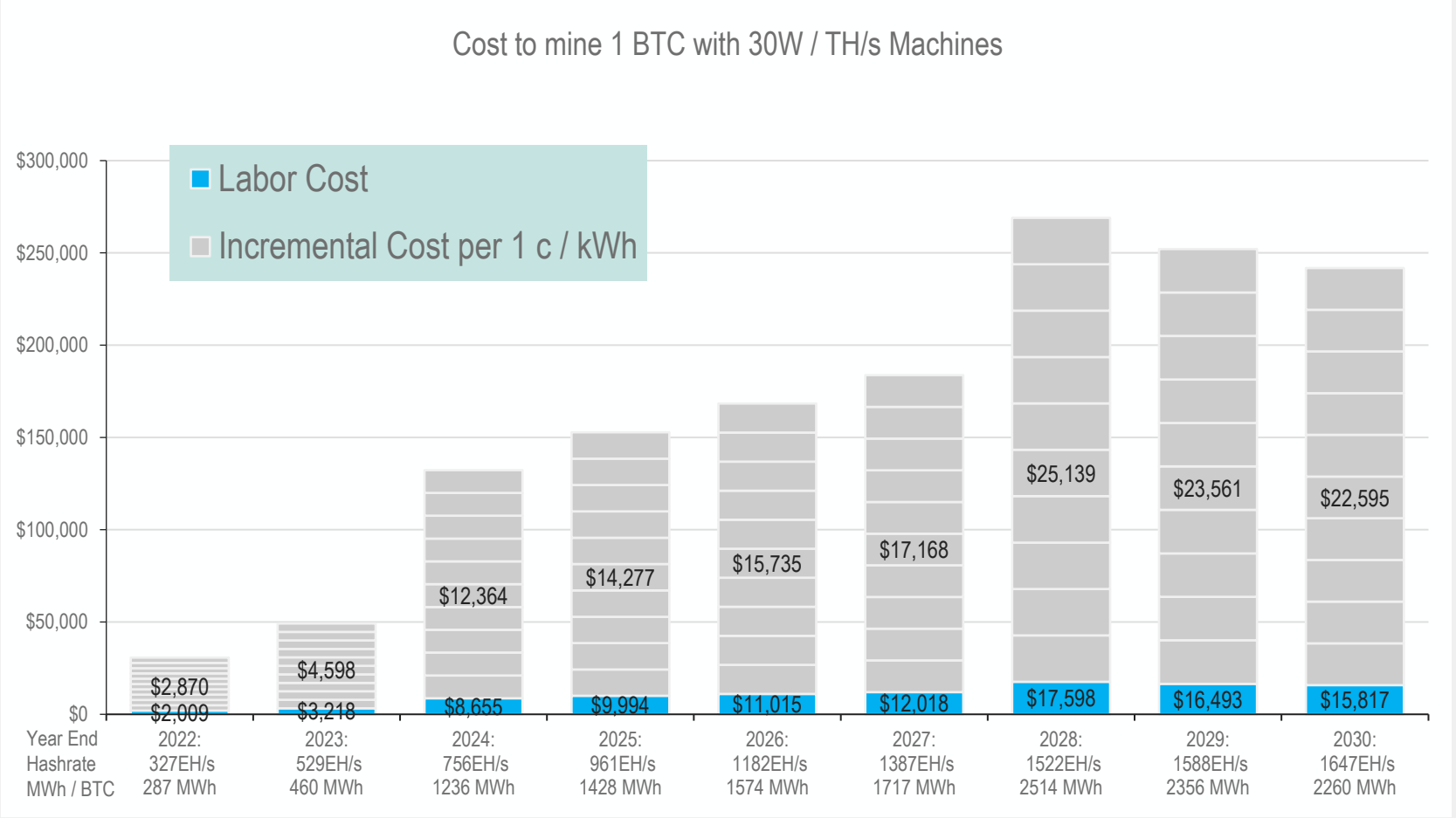


Figure: Cost to mine 1 Bitcoin using a 30 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 25W / TH/s Rigs

- By YE 2022, it should take $1,674 in labor and $2,392 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 25W machines would be $1,674 + 2,392 x 2 = $6,458

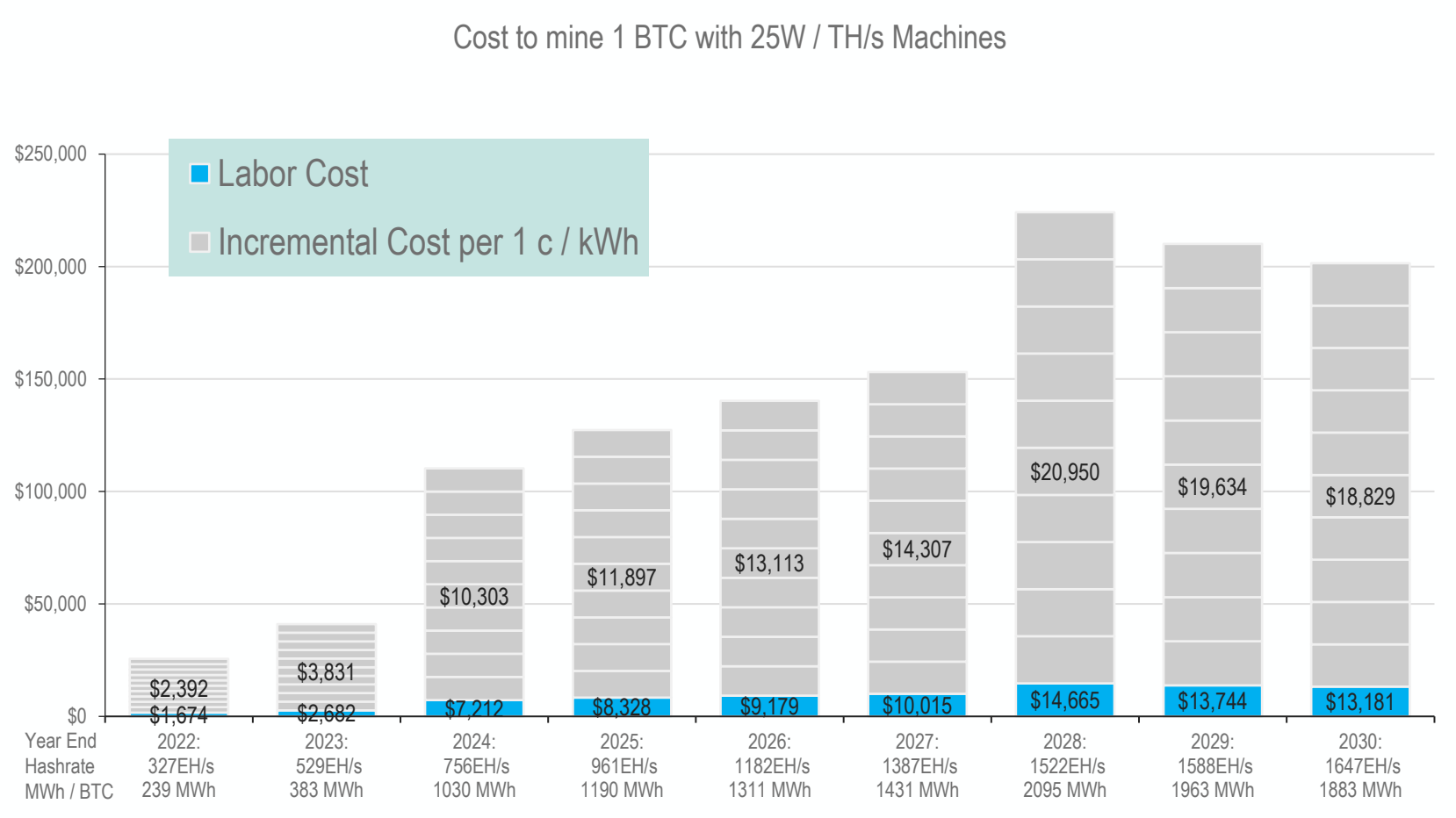


Figure: Cost to mine 1 Bitcoin using a 25 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 20W / TH/s Rigs

- By YE 2022, it should take $1,339 in labor and $1,914 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 20W machines would be $1,339 + 1,914 x 2 = $5,167

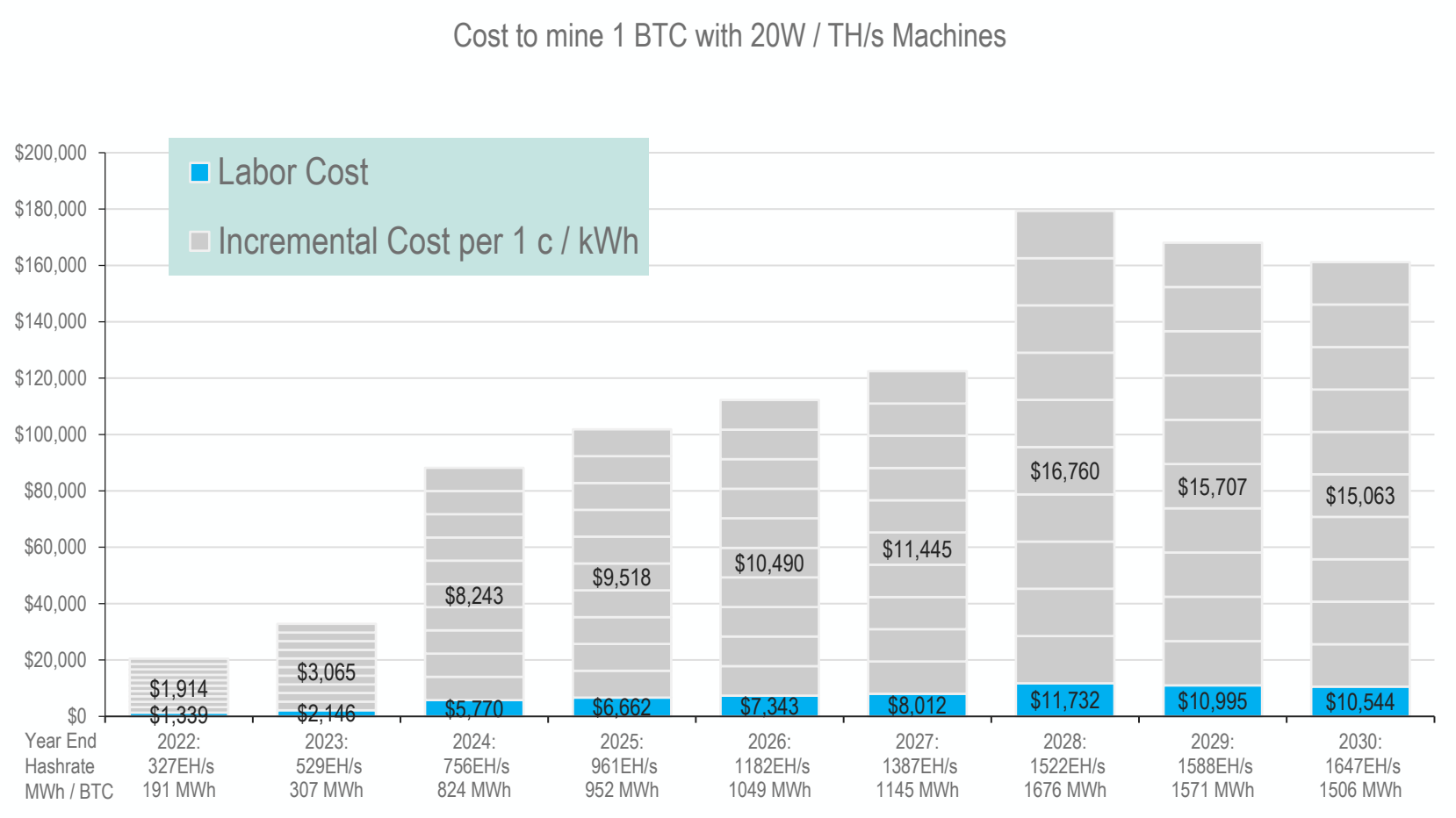


Figure: Cost to mine 1 Bitcoin using a 20 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 15W / TH/s Rigs

- By YE 2022, it should take $1,005 in labor and $1,435 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 15W machines would be $1,005 + 1,435 x 2 = $3,875

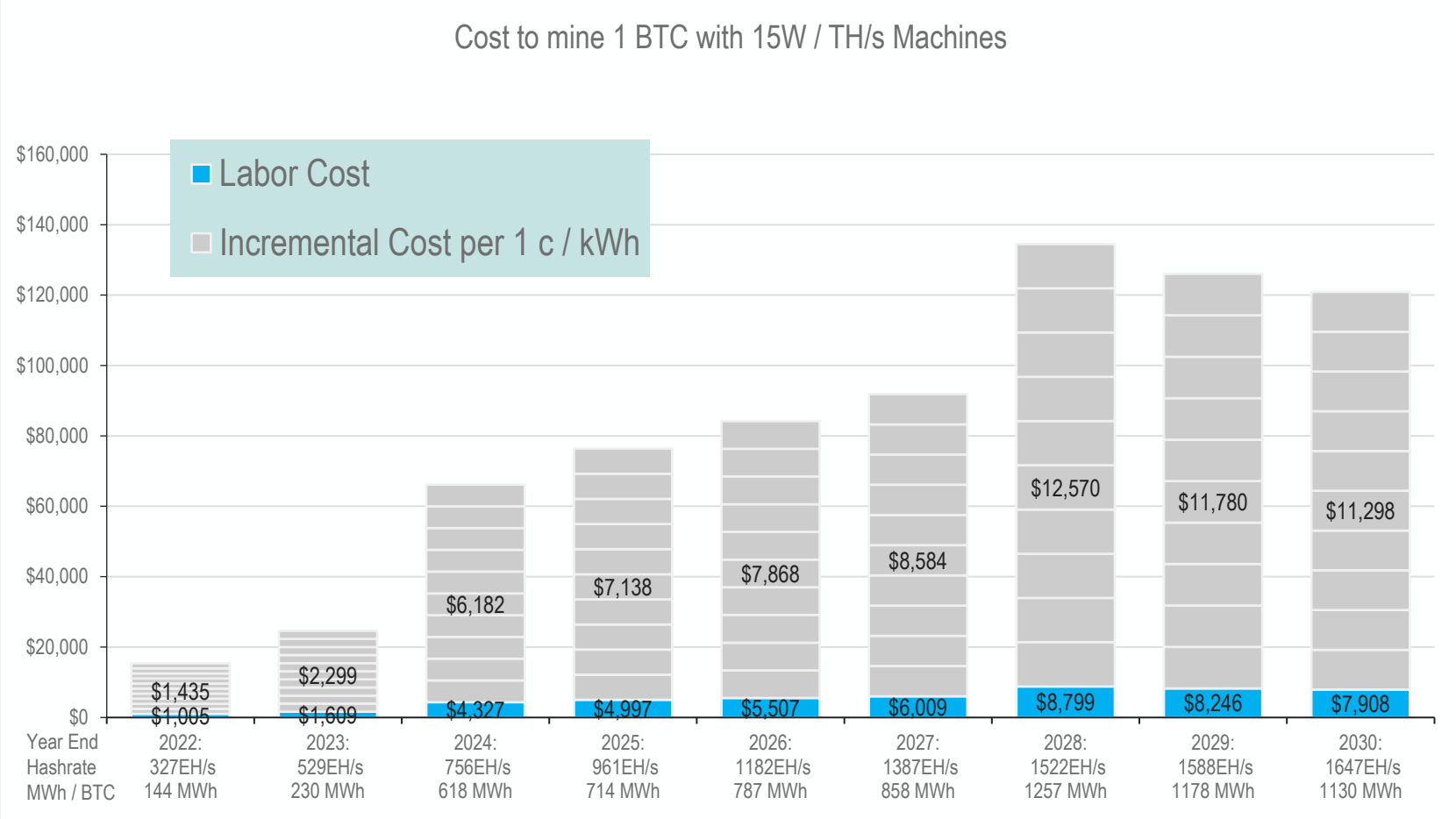


Figure: Cost to mine 1 Bitcoin using a 15 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 10W / TH/s Rigs

- By YE 2022, it should take $670 in labor and $957 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 10W machines would be $670 + 957 x 2 = $2,584

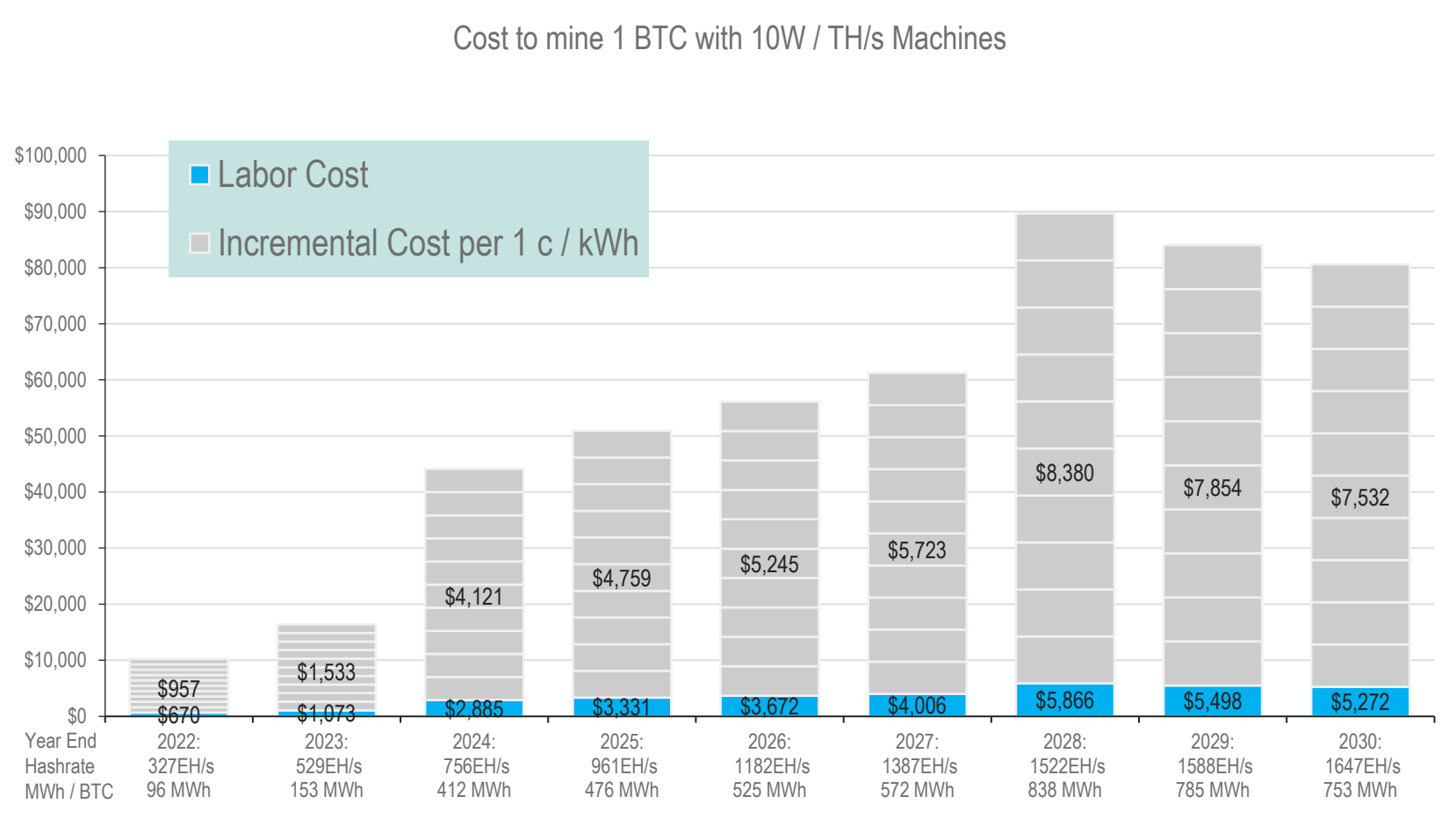


Figure: Cost to mine 1 Bitcoin using a 10 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Cost to Mine 1 BTC
Using 5W / TH/s Rigs

- By YE 2022, it should take $335 in labor and $478 in power cost per 1c/kWh price to produce 1 BTC
- Thus, if a miner's power cost was 2 c/kWh, the cost to produce 1 BTC on 5W machines would be $335 + 478 x 2 = $1,291

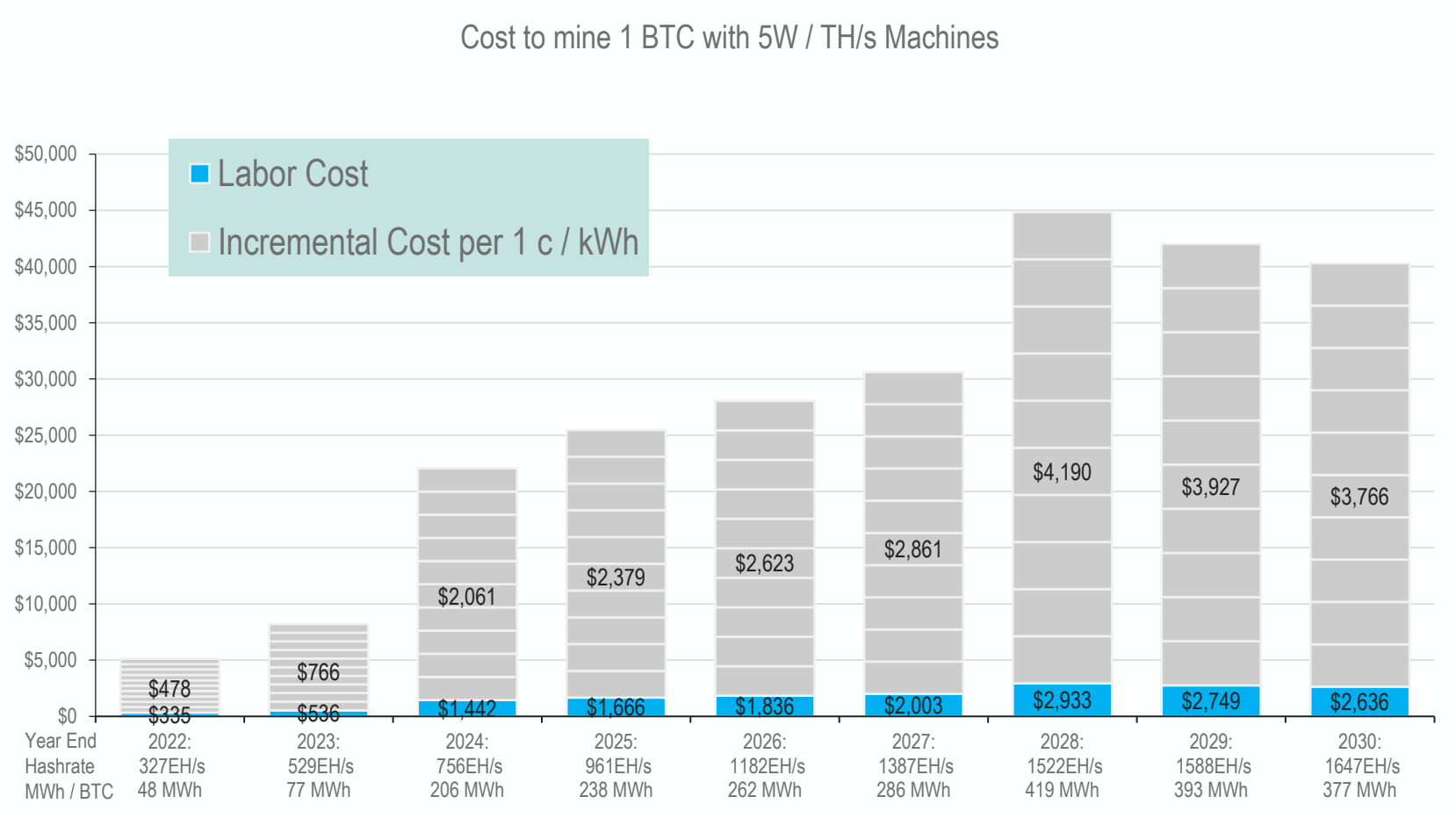


Figure: Cost to mine 1 Bitcoin using a 5 W/TH/s rig, where each grey segment represents 1 c / kWh; for example, the top of the stack shows labor cost plus 10 x cost per 1 c / kWh

Source: BitOoda, CoinMetrics, Bloomberg

Risks to Our Estimates

- Hashrate estimates are notoriously challenging
- Constraints include semiconductor capacity, power availability, and miner profitability, which is essentially a spread between Hashrate growth and price growth
- Capital flows are another constraint: strong profitability has attracted fresh capital to supplement internal generation within the industry. However, a sustained bear market could cause capital flows to dry up
- In such a scenario, it is an open question whether all rig and site / power commitments are fully funded, or whether capital could dry up in a sustained Bitcoin bear market, leading to miners defaulting and unable to make balance payments and accept delivery
- Significant price movements, regulatory or environmental challenges, supply chain disruptions and capital market conditions could affect the realized Hashrate
- With the crypto mining ban in China, power availability becomes a key constraint
- Specifically, the constraint is on power infrastructure including substations, transformers and breakers
- Due to long lead times on these items, any mining capacity either relocating out of China or future deliveries to China getting relocated elsewhere, may have a hard time finding sites that are ready to turn the machines on
- The situation in Kazakhstan adds further to the uncertainty, considering that much of the Hashrate that relocated out of China went to Kazakhstan, and might end up being stranded there
- However, we believe our long-range forecasts are intact, subject to the mining profitability constraint
- While semiconductor access is constrained, overall volumes appear modest to us, and could allow Hashrate to surprise meaningfully to the upside over time if mining profitability warrants it – i.e., if BTC price appreciation largely keeps pace with Hashrate growth
- Significant price downside could cause order pushouts, defaults and shut-ins. Hashrate will respond to price, especially in a price recovery off a bottom to the extent such a bear-market scenario results in unsold ASIC inventory buildup and rationalizing rig prices
- **Subject to the price of Bitcoin, we believe risks to our Hashrate estimates are balanced**

Disclosures

Purpose

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Sam Doctor, the research analyst denoted by an "AC" on the cover of this report, hereby certifies that all of the views expressed in this report accurately reflect his personal views, which have not been influenced by considerations of the firm's business or client relationships.

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