We attempt to measure, locate and price power capacity, and estimate miner profitability in the context of potential future Hashrate and capital constraints.

We assess that the BTC mining industry utilizes ~65% of 9.6GW (slide 11, growing at ~10% p.a.) of available power capacity, powering 2.8mm dedicated bitcoin mining rigs. Most current devices are S17 class (slide 48), but future growth will largely come from next-gen S19 class mining rigs (slide 28).

We identified 4.1GW of this power capacity across 153 mining sites, including power prices at 67 sites representing ~3GW, by speaking with miners, rig manufacturers, resellers and public sources (slide 14).

Our conversations lead us to believe that we have accounted for ~80% of US / Canadian capacity, but just ~15% of Chinese capacity. If accurate, this would imply a 50% market share for China-based miners, followed by the US at 14% (slide 15).

We assess the median power price at 3c/kWh (slide 17) and median cash cost to mine BTC at ~$5000 (slide 20). Slide 21 shows S9 class rigs need <2c/kWh power for viability, while S19s are viable to 9c/kWh.

China’s hydro season shifts the cost curve down (slide 23), which supports capital accumulation, BTC price appreciation (slide 25), and subsequent hash growth with a 4-6 month lag (slide 26).

Upgrade cycle could take Hashrate to 360 EH/s in two years and 260 EH/s in 1 year (slide 28), led by available power capacity and the replacement of S9s and S17s by S19 class rigs (slide 30). We have not assessed potential impacts of future rig upgrades.

Increases in Hashrate and difficulty would reduce BTC flow per PH/s (slide 35) and per MWh (slide 37). Miner economics could weaken, needing a BTC price of $21000 to offset the lower BTC flow per PH at 260EH/s, and $29000 to offset 360 EH/s (slide 34). A $1000 price increase is needed to offset each 10EH/s increase in Hashrate (Slide 38).

$4.5B Capex is needed over 12 months, $6.3B to fully fund the upgrade cycle (slide 40). Even with an assumed 35% per annum price appreciation to $15,500 by YE 2021, a $4.1B funding gap remains vs. cash generation (slide 43).

Risks to our thesis

- Price action could reduce funding needs or delay achieving our Hashrate projections. Slide 34 shows revenue sensitivity vs. device cash operating cost at different network Hashrate assumptions.
- Increased access to cheap power could drive Hashrate higher, although limited by diminishing BTC revenue per MWh (slide 37).
- Semiconductor capacity / ASIC shipments could drive variance to our model – although we note that the industry has previously delivered significantly more units than our model assumes (slide 44).

In Summary: Current BTC network power capacity is ~9.6GW (~50% in China, 14% in the US), driving 121EH/s of computing Hashrate. We assess that Hashrate could reach 360EH/s in two years, led by an upgrade cycle, falling median power prices from the current 3c / kWh level, and ~$4.1B external funding into the mining industry. Cheap power, BTC price and semiconductor shipments are key risk factors.

Key Takeaways

- About 50% of 9.6 GW global mining power capacity is likely in China; the US is at ~14%; capacity utilization is ~ 67%
- Median BTC mining power cost is 3c / kWh and cost to mine 1 BTC is ~$5000
- Hashrate could reach 260 & 360 EH/s in 12 & 24 months with upgrade cycle but needs $6.3B Capex; funding gap is $4.1B vs. industry cash generation
- Price needs to appreciate by $1000 for every 10EH/s increase to stay revenue neutral per MWh
- Cheap power, BTC price and semiconductor shipments are key risk factors to our estimates

Please see slide 50 for important disclosures
Foreword
The Importance of Bitcoin Mining Research

Bitcoin is a digital commodity that spurred the emergence of a new asset class. One of the defining characteristics of this new asset class is that ownership of the asset’s units is recorded on a distributed ledger.

Bitcoin miners update the Bitcoin ledger (i.e., add new blocks of transactions to the ledger) by operating costly, specialized hardware and consuming large amounts of energy. By doing so, miners perform transaction settlement and secure the ledger. As such, Bitcoin mining is a foundational component of the network and Bitcoin as an asset. Despite its importance, mining has been among the least transparent and the least understood part of the broader Bitcoin ecosystem.

Miners are not required to register and get a license to be part of the Bitcoin network – the system is permissionless and that is what makes it robust, more decentralized, and ultimately secure. Due to its open and pseudonymous attributes, it is not possible to directly observe the actual composition of the mining network – by location, size and type of operation, equipment used, or the economics and profitability. All of this is important macro data that would help us understand the state and health of the system and identify trends and make predictions on how it may be evolving.

This report by BitOoda serves to improve the transparency related to the composition of Bitcoin miners. BitOoda leveraged its extensive network to survey 67 mining sites. This data, combined with secondary research of publicly available data, allowed them to locate a total of 153 mining sites with operations in 20 countries, comprising more than 40% of the global network Hashrate. Although further assumptions had to be made, this valuable dataset allowed them to draw some interesting insights such as Bitcoin’s global production cost curve, the network’s total power consumption, and is useful in making predictions about the network Hashrate growth.

While no research report about the state of Bitcoin mining can draw definitive conclusions, research studies with transparent and sound methodologies like this shed more light on the industry. When the results from multiple such independent studies are combined, one can make conclusions about the mining ecosystem with more confidence.

Fidelity Center for Applied Technology (FCAT) started mining bitcoin in 2014 with research as our main objective. In 2018, we organized the Mining Summit, a two-day, free and public event, with the goal of sharing our learnings and educating the broader community about the state and importance of mining. This year we decided to sponsor this research project conducted by BitOoda centered around the power cost analysis for the Bitcoin mining network.

We look forward to continuing our research of the Bitcoin mining space and helping to push the ecosystem forward. We thank the BitOoda team for their work, which we hope will elevate everyone’s understanding about this complex and fascinating part of the Bitcoin ecosystem.

Juri Bulovic
Fidelity Center for Applied Technology
About Us:

**BitOoda:**
Founded in New York in 2017, BitOoda set out to become the leading digital asset fintech firm. The company was created to deliver transparency and accelerate the global adoption of transformational technologies by promoting efficient marketplaces through innovative and professional capital markets solutions. Founders Tim Kelly and Rob Madden leveraged their expertise to create a financial technology and services firm that aims to evolve digital asset markets through an innovative data-driven platform that offers next-generation financial products, high-touch brokerage services, and applied research solutions that put our clients’ interests first.

Today, BitOoda has become a pioneer in the digital finance space. We have:

- Established a brand as an authority for institutional solutions in the digital economy through product engineering – including our proprietary BitOoda Hash™ Bitcoin Hashpower Contract, BitOoda Difficulty™ Swap and BitOoda Transaction Fee™ products.
- Developed an industry-leading distribution & execution capability in our role as an Agency-only broker, including building foundational relationships with firms across the digital asset ecosystem, including funds, projects, data centers, capital markets participants, and service providers.
- Led the digital asset community’s regulatory development through our SEC-regulated Broker Dealer, our CFTC-regulated Introducing Broker, and our principal leadership role as a founding member of the Association for Digital Asset Markets (ADAM), a trade group focused on defining industry standards for the advancement of fair and orderly markets.
- Applied advanced technologies and data analytics to design a suite of proprietary data products and indices that give our clients unique advantages to optimize their positions and manage risk.

For more information on BitOoda, please visit our [website](#) or contact us at [info@bitooda.com](mailto:info@bitooda.com)

**Sam Doctor:**
Sam Doctor, the principal author of this report, is Chief Strategist at BitOoda.

Sam Doctor’s flagship research includes both project evaluations and Bitcoin mining analyses focused on Bitcoin mining profitability and risk factors. His aim, as the Chief Strategist at BitOoda, is to apply a variety of capital markets tools to enable investors and projects to reduce risk, enhance returns and overcome barriers to adoption.

Mr. Doctor is a veteran finance professional with over 18 years research experience, covering technology stocks, macro and quantitative strategy and cryptocurrency research, formerly at JPMorgan in New York and Asia, and more recently as the Head of Data Science and Quant Research at Fundstrat Global Advisors.

Mr. Doctor holds a Finance & Strategy MBA from the prestigious Indian Institute of Management, Ahmedabad and is an Electronics and Semiconductor engineer from the University of Mumbai, India. He holds his Series 7, 63, 86 and 87 licenses with FINRA.

More information is on his [LinkedIn](https://www.linkedin.com) page.
Analyzing the Bitcoin Network

Research Methodology
The BitOoda Hash Dashboard
Network Power Capacity
Miners’ Geographic Distribution
Mining Cost Curves
Effects of China’s Hydro Season
Future Outlook for Hash
Price, Power and Production Capacity Constraints
Appendix and Sources
Research Methodology
The Bitcoin Network: Demystifying Mining

Bitcoin mining is a secretive industry, with very little publicly available information. We find that even many sophisticated crypto investors have gaps in their understanding of mining and potential investment opportunities in the space. Despite stellar research by Coinmetrics, Coinshares, and the Cambridge Center for Alternative Finance, unanswered questions remain. This research has been commissioned by Fidelity Center for Applied Technology (FCAT) and independently conducted by BitOoda. We aim to add to the existing body of research, building upon prior research and attempting to address new questions.

Research Objectives

In this research project, we set out to answer some of the age-old questions around Bitcoin mining, starting with how much power does the network draw; how much power can it currently draw and how this capacity is growing.

We also aim to identify the distribution of mining capacity globally, both by geography and by the cost of power, with an aim to develop a power cost and Bitcoin mining cost curve, based on bottom up survey research.

Further, we aim to identify the available computing or Hashpower in the mining network, and estimate how much it could grow in the coming 24 months or so. Additionally, we model the capital investment entailed in achieving this Hashrate, and the constraints involved – semiconductor capacity, internal cash generation by the mining industry, diminishing returns with rising Hashrate (a function of the price of Bitcoin) and available external funding.

Methodology

We spoke with every miner and rig manufacturer and reseller we could identify (more than 60 conversations), requesting data on facility size, location, and power price, while promising anonymity, which is critical to this highly secretive community. Power price is the single largest industry cost, and a primary source of competitive advantage.

In addition, we surveyed 45+ public sources such as company websites, press releases and media interviews with miners to piece together what information we could obtain.

We gathered size and country data on 131 miners (153 sites across 20 countries), totaling 4GW of available power. Of these, we obtained power prices on 66 sites, either as a point estimate – such as 1.8c / kWh or a range (e.g. between 2-3c/kWh), totaling about 2.9GW of available power capacity. We also did research into the impact of China’s hydro season on the mining community – with surprising results.

We used this data to build a cost curve of power price for the known capacity, and a curve representing the cash cost to mine 1 Bitcoin, making standardized assumptions such as a power usage effectiveness factor of 1.12. (For every unit of power used to mine Bitcoin, 12% excess is consumed for everything else – cooling, lighting, routers / switches and other facility power overhead.) We then plot out the percentage of Bitcoin mined at different cost levels, based on the distribution of power prices.

Additionally, we modeled what we believe is a lower bound for the aggregate power capacity in the Bitcoin network of 9.6GW, and estimated that it could grow at a minimum of 10% a year, using simplifying assumptions detailed in the report.

Finally, we examined the potential network Hashrate if all the available electricity in the network powered latest-generation rigs, and its security implications. We then estimate the capital investment required to achieve that potential Hashrate, as well as the funding gap – external funding required to bridge the difference between the capex need and the internal cash generation within the network. We take note of the key constraints to Hashrate growth: available cheap electricity, capital availability, equipment availability, lead times and production constraints, and the impact of BTC price on the value of diminishing BTC rewards per production unit as the network grows.

We conclude with our 18-24 month outlook for the Bitcoin Mining Network.

Takeaways

• Current BTC network power capacity is ~9.6GW (~50% in China, 14% in the US), driving 121EH/s of computing Hashrate.

• We assess that Hashrate could reach 360EH/s in two years, led by an upgrade cycle, falling median power prices from the current 3c / kWh level, and ~$4.1B external funding into the mining industry.

• Cheap power, BTC price and semiconductor shipments are key risk factors.

• We do NOT make any price forecasts, and merely use different price scenarios to model potential impacts on network Hashrate and miner profitability and capital investment.
Bitooda Hash™
Dashboard

- A regular publication that shows the state of the Bitcoin mining network: Price, Hashrate, Number of Blocks mined, Difficulty, and other metrics.

- We show the expected revenue per PH/s Day and per MWh as a measure of miner profitability.

- Our model shows estimated power cost curves and Bitcoin mining cost curves, as well as the cost to mine 1 BTC using different generations of mining rigs, at different power prices.

- We further plot our model estimates of network Hashrate, power consumption, installed base of mining rigs by generation, and revenue curves per MWh for each generation of rig, at different network Hashrate.

- Finally, we end with our estimates of the geographic distribution of mining capacity and our projections of the network Hashrate.
BitOoda Hash™ Dashboard

AS OF:
08:00 AM ET
July 14, 2020

BTC Network Power Cost Curve

Cash cost to mine 1 BTC

Known Data
Upper Bound
Lower Bound

Known Capacity
(BitOoda Est)

US
615 MW
China
731 MW
Canada
465 MW
Russia
465 MW
Kazakhstan
465 MW
Iran
465 MW
Iceland
165 MW
Rest of World
91 MW

Est. capacity share known

USA
15.0%
China
15.0%
Canada
60.0%
Russia
60.0%
Kazakhstan
60.0%
Iran
60.0%
Iceland
90.0%
Rest of World
33.2%

Distribution of Total Capacity

USA
50%
China
50%
Canada
14%
Russia
8%
Kazakhstan
8%
Iran
8%
Iceland
2%
Rest of World
3%

Known Data
Upper Bound
Lower Bound

S9 Class: 0.0027BTC ($25)
S17 Class: 0.0058BTC ($54)
S19 Class: 0.0095BTC ($88)

Revenue per MWh

Mining Stats: BitOoda Ests

S9 Class
S17 Class
S19 Class

Hashrate Projections: 260 EH/s in 12, 360 EH/s in 24 months

Metrics assume Bitmain S19 as a representative net-gen device, unless specified

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Source: BitOoda, Coinmetrics, Kaiko, EIA
Network
Power Capacity
Understanding Miner Economics amid Stagnant BTC Price

- Bitcoin price was range bound through the block reward halving in May 2020
- Hashrate peaked just prior to the event, and has yet to fully recover from the crash immediately afterward. Mining economics have weakened considerably
- This report attempts to measure, locate and price power capacity and forecast changing miner profitability in the context of potential future Hashrate and capital constraints

Figure: Bitcoin price and rolling changes
Note: Since 2014; data as of 7/14/2020

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics

For exclusive use of BitOoda clients. Do not redistribute.
At least 9.6GW available to BTC mining network

- The Hashrate peak in early May needed 9.6GW of power consumed by the Bitcoin mining network, assuming capacity shut-ins that took Hashrate down to 82EH/s by mid May were all older generation rigs
- The Hashrate bottom corresponds to just 3.9GW of power draw

Figure: Bitcoin Hashrate and power consumption at recent peak / trough
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
Hashrate of 124EH/s implies 6.4GW and 2.8mm devices in operation

- Capacity utilization is 67% of available power
- New devices drive efficiency gains
- The upgrade cycle to S19 class rigs should drive hash growth, which we examine in detail in the Future Outlook section

Next-gen rigs = 18% of Hashrate

<table>
<thead>
<tr>
<th>Hashrate</th>
<th>Power Consumption</th>
<th>Rig Installed Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>123850 PH/s</td>
<td>22627 PH/s</td>
<td>205,696</td>
</tr>
<tr>
<td>85742 PH/s</td>
<td>669 MW</td>
<td>1,105,823</td>
</tr>
<tr>
<td>15482 PH/s</td>
<td>4128 MW</td>
<td>1,531,106</td>
</tr>
<tr>
<td>6423 MW</td>
<td>1627 MW</td>
<td>2,842,625</td>
</tr>
<tr>
<td>18% of Hashrate</td>
<td>10% of power</td>
<td>7% of operating</td>
</tr>
<tr>
<td></td>
<td>consumption</td>
<td>devices</td>
</tr>
</tbody>
</table>

Figure: Bitcoin Hashrate, power consumption and installed base of rigs
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin
As of 7/14/2020

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
Miners’ Geographic Distribution
Bottom up research identifies geographic distribution of 4.1GW of Mining Capacity

- We identified about 4.1GW of power through bottom-up research, including direct conversations with miners, rig manufacturers/dealers, and public sources such as filings, press releases and miner interviews.
- Our data spans 153 mining sites, skewed towards the US and Canada.
- Of these 153, we have power prices for 67, totaling ~3GW of capacity.

Figure: Geographic distribution of surveyed mining capacity

Note: Some of the underlying data was shared under condition of anonymity.
As of 7/14/2020

Source: BitOoda estimates, Miners, ASIC makers/resellers, public sources
Geographic Distribution: Estimated Network Power Capacity

- Based on conversations with individual miners and resellers, we assess that about 80-90% of US, Canada and Iceland-based mining capacity has been identified, but perhaps just 15% of Chinese capacity
- Applying these rough estimates, we believe China represents 4.9GW or 50% of all available power for Bitcoin Mining, followed by the USA (14%)

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity (MW)</th>
<th>Share</th>
<th>Known Cap. Distribution</th>
<th>Identified Cap. Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>1313</td>
<td>14%</td>
<td>85.0%</td>
<td>85.0%</td>
</tr>
<tr>
<td>China</td>
<td>4873</td>
<td>50%</td>
<td>15.0%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Canada</td>
<td>721</td>
<td>7%</td>
<td>60.0%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Russia</td>
<td>775</td>
<td>8%</td>
<td>60.0%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>758</td>
<td>8%</td>
<td>60.0%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Iran</td>
<td>750</td>
<td>8%</td>
<td>90.0%</td>
<td>90.0%</td>
</tr>
<tr>
<td>Iceland</td>
<td>183</td>
<td>2%</td>
<td>33.2%</td>
<td>33.2%</td>
</tr>
<tr>
<td>Rest of World</td>
<td>274</td>
<td>3%</td>
<td>1116 MW</td>
<td></td>
</tr>
</tbody>
</table>

Source: BitOoda estimates, Miners, ASIC makers, Public sources

Figure: Geographic distribution of surveyed and estimated global mining capacity
Note: Some of the underlying data was shared under condition of anonymity
As of 7/14/2020
Bitcoin Network
Cost Curve
**Power cost curve**

**BTC Mining Network**

- We identified size and power costs for facilities representing roughly 31% of the estimated maximum power consumption of the Bitcoin network.
- Extrapolating to the rest of the network, we think 50%+ of capacity is at under 3c/kWh power cost.
- The confidence interval / outer bounds for sub-3c power is about 35% - 55%.

*Figure:* Power cost curve: Mapping power cost vs. share of network capacity

*Source:* BitOoda estimates, Miners, ASIC makers, Public sources

*As of 7/14/2020*
Estimated 80% utilization
Within known power cost sources

- We believe low-cost miners are running near full capacity, while higher cost miners are operating at about 2/3 capacity, within the known 31% of identified capacity
- Utilization in sample may be higher than the broader industry, because our sample may have a more efficient rig mix vs. the general miner population
- Weighted average cost to mine 1 BTC ~$6500

### Table: Power Cost Known Capacity

<table>
<thead>
<tr>
<th>Power Cost</th>
<th>Known Capacity</th>
<th>Share of Known Capacity</th>
<th>Total Capacity (if mix = known capacity mix)</th>
<th>Range of Total Capacity</th>
<th>Share of Total Capacity</th>
<th>Wt. Avg Cash Cost /BTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 1c/kWh</td>
<td>450 MW</td>
<td>15.1%</td>
<td>1454 MW</td>
<td>450 - 1705 MW</td>
<td>5.1%</td>
<td>$3,323</td>
</tr>
<tr>
<td>1c/kWh - 2c/kWh</td>
<td>604</td>
<td>20.2%</td>
<td>1951</td>
<td>1269 - 2092</td>
<td>6.9%</td>
<td>$4,492</td>
</tr>
<tr>
<td>2c/kWh - 3c/kWh</td>
<td>198</td>
<td>6.6%</td>
<td>635</td>
<td>574 - 771</td>
<td>2.3%</td>
<td>$5,250</td>
</tr>
<tr>
<td>3c/kWh - 4c/kWh</td>
<td>733</td>
<td>24.5%</td>
<td>2157</td>
<td>2299 - 2605</td>
<td>8.3%</td>
<td>$6,961</td>
</tr>
<tr>
<td>4c/kWh - 5c/kWh</td>
<td>600</td>
<td>20.1%</td>
<td>1766</td>
<td>1797 - 2250</td>
<td>6.8%</td>
<td>$8,256</td>
</tr>
<tr>
<td>5c/kWh - 6c/kWh</td>
<td>280</td>
<td>9.4%</td>
<td>858</td>
<td>804 - 960</td>
<td>3.2%</td>
<td>$10,102</td>
</tr>
<tr>
<td>6c/kWh - 7c/kWh</td>
<td>92</td>
<td>3.1%</td>
<td>279</td>
<td>92 - 314</td>
<td>1.0%</td>
<td>$11,437</td>
</tr>
<tr>
<td>Above 7c/kWh</td>
<td>30</td>
<td>1.0%</td>
<td>-312</td>
<td>30 - 169</td>
<td>0.3%</td>
<td>$13,823</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2987 MW</td>
<td>100.0%</td>
<td>8788 MW</td>
<td>34.0%</td>
<td><strong>$6,561</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Sampled power capacity: Available and Utilized

- Source: BitOoda estimates, Miners, ASIC makers, Public sources
- As of 7/14/2020

Figure: Capacity / utilization cost for sampled miners and estimated network power capacity
3-4c/kWh Modal Power Cost: Capacity at different price points

- We extrapolated power capacity at different price points for the 9.6GW of estimated total Bitcoin mining capacity based on the known prices for the 3GW of capacity in our research sample.
- We estimate upper / lower / mid bounds of capacity based on whether the mix of unknown 69% of power capacity is at a lower or higher price vs. the known capacity.

**Figure:** Power distribution: Lower, median and upper bounds of capacity at each power price point

As of 7/14/2020

Source: BitOoda estimates, Miners, ASIC makers, Public sources
Cash cost to mine 1 BTC

- Based on our cost curve estimates, the median cash expense to mine 1 BTC is ~$5000.
- We assess the upper confidence interval on median cost is ~$6000, assuming the unknown power sources have a higher power cost mix than our known data.

Figure: Cost to mine 1 BTC, based on network capacity at different power costs

Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin.
As of 7/14/2020

Source: BitOoda, Miners, ASIC makers, Public sources.
Daily Revs vs Cost per PH/s:
Need sub-2c / kWh to run S9s

- The columns in the chart below show the daily operating cost to run each device class, in 1c / kWh power cost increments.
- The lines show the dollar value of Bitcoin mined per PH/s per day at current prices, and if BTC were $11000 or $13000.
- S9 class rigs need sub-2c / kWh power to be viable, but S17 class is viable up to 6c / kWh; S19 class up to 8c / kWh.

Figure: Daily revenue and cash operating costs using different rigs at different power price, at current Hashrate.
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin.
Power Costs:
Effects of China’s Hydro Season
Hydro Season = Lower Power Cost

- China accounts for as much as 65% of global Hashrate per Cambridge Center for Alternative Finance; our estimates are somewhat lower at about 50%
- Much of this computing power operates at 2.5-3c/kWh in Inner Mongolia during the dry season
- During flood season, these miners migrate significant capacity to Sichuan and Yunnan provinces to take advantage of as low as sub-1c/kWh power

- An S9 rig generates $28/MWh in revenue, which means that it could be profitable to mine Bitcoin using older generation, depreciated rigs.
- Furthermore, even with newer equipment, dropping the price of electricity from $25-30 to $10/MWh increases profitability meaningfully.
- Assuming an additional $7/MWh as labor/overhead – which may be high in the Chinese context – the cash contribution for an S17 class rig would double from $21 to $41.
- For a sample 50MW facility running S17 class equipment, this is $4.4 million in incremental cash flow to fund rig upgrades and capacity expansion, to a total of $8.8 million.
- This would allow the S17 class miner to buy over 3500 next gen S19 class rigs, or upgrade/expand 12MW of their capacity.
- We think the upper end of the cost curve is unaffected: 4c+ / kWh power is less migratory.

Figure: Power cost curve shifts during China’s flood season
Source: BitOoda estimates, Miners, ASIC makers, Public sources
Hydro Season enhances capital accumulation, supporting BTC Price Appreciation

- During Hydro season, Chinese miners are accumulating capital for reinvestment.
- In the prior example, BTC price / network Hashrate being equal, the hypothetical 50MW miner would have to sell $8M in BTC during the dry season to meet operating expenses, but just $3.7M during the flood season.
- Across multiple GW of migratory power capacity in China, that is about $1+ billion of incremental BTC accumulated and transferred "off exchange" between miners and rig manufacturers who accept payment in crypto currency.
- Miners pay for their rigs several months in advance to secure shipment of rigs from suppliers like Bitmain, Canaan or MicroBT. The suppliers in turn make advance payments for wafer capacity at foundries such as TSMC, with a typical 12-13 week lead time.
- While this BTC does get eventually sold to the market to pay TSMC and other semiconductor foundries in fiat, we believe the discretionary timing of this sale allows for more favorable trading strategies.
- Absent similar seasonality in fiat flows buying into crypto and BTC in particular, there is consistent fiat flow seeking to absorb less BTC flow during hydro season. Also, there is a feedback loop where fiat flows increase following BTC price appreciation.
- In our view, this dynamic supports the pattern of higher price appreciation for Bitcoin during the Chinese flood season.
Hydro Season ≠ Hashrate Growth

- Average Hashrate growth is consistent between Flood and Dry seasons
- But over 6 years price appreciation appears higher during Flood seasons

**Figure:** Hashrate and BTC price segregated by flood and dry seasons

**Note:** Since 2014; averages exclude Nov 2013-Oct 2014

**As of 7/14/2020**
Price changes lead Hashrate change

- We examined the correlation between trailing price growth and Hashrate growth over periods ranging from 15 days to 1 year.
- Highest correlation region shows that price appreciation over several months drives Hashrate growth, with a 4-6 month lag.

Figure: Correlation between price changes and Hashrate changes
Note: Past 12 months
As of 7/14/2020

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
260+ EH/s Hashrate Potential by June 2021

- At 10% growth in power capacity, the industry could draw 10.6 GW in 1 year
- This is based on a combination of miners’ expansion plans, discounted since not every planned expansion will come to fruition, and potential shutdown of higher-priced power capacity
- We believe new devices will be a mix of S17 and, mostly, S19 class
- Hashrate could exceed 260 EH/s in 1 year

Figure: Bitcoin Hashrate and power consumption
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin
As of 7/14/2020

Source: BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
~10.6GW power capacity
Fully utilized by mid 2021

- We believe a negligible quantity of S9 class rigs will remain in operation after November 2020, barring a large surge in Bitcoin price
- While some S17 class shipments will continue, a growing share of new rigs will be S19 class

Figure: Bitcoin power consumption by device class
As of 7/14/2020

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
Hashrate 260 EH/s in 1 yr
Driven by upgrade cycle

- The upgrade cycle should drive Hashrate to 260 EH/s in 1 year, and to 360 EH/s in 2 years
- Power capacity is the boundary condition: upside to this number could expand Hashrate faster
- Near term, shipment delays from China, and especially delays from Bitmain, could pose a downside to our base-case hash estimates

Figure: Bitcoin Hashrate by device class
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin
As of 7/14/2020

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
Hashrate growth rates will likely moderate...

Despite Hashrate rising to 360EH/s, we think growth will begin to moderate in 2022

Figure: Bitcoin Hashrate and rolling changes
Note: Since 2014; data as of 7/14/2020

Source: BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
Difficulty could more than triple in 24 months

Increasing Hashrate could drive difficulty monotonically higher

Figure: Bitcoin Difficulty and rolling changes
Note: Since 2014; data as of 7/14/2020

Source: BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
Difficulty growth moderates but continues...

Difficulty changes are a reflection of changing hashrate, led by rig upgrades, available power capacity growth and, occasionally, by price declines driving shut-ins of older rigs or higher power cost facilities.

Figure: Bitcoin difficulty reset history
Note: Since Nov 2013, sequential epoch change, %; data as of 7/14/2020

Source: BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
Hashrate ↑ = less BTC/PH/s: Weakening economics

- As Hashrate rises, 1 PH/s earns a falling share of daily revenue
- Thus, at flat BTC prices, profitability erodes, and an increasing proportion of mining capacity – both older rigs and entire facilities – become unviable
- At 260EH/s, mining at $19,500 BTC price is about as profitable as at <$9220 today; at 360EH/s, price would need to be $27,000 to match today’s profitability (see slide 20)

<table>
<thead>
<tr>
<th>Network Hashrate</th>
<th>S9 Class</th>
<th>S17 Class</th>
<th>S19 Class</th>
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</table>

- Breakeven power prices could degrade meaningfully with rising hash

<table>
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<th>S17 Class</th>
<th>S19 Class</th>
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Figure: Daily revenue and cash operating costs using different rigs at different power price, at several future hashrates.
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin.

Source: BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
**BTC Flow per PH/s falls as Hashrate increases**

- As shown on previous slide, higher network Hashrate drives weaker economics
- Any offsetting price increase assumptions loom large in the viability of new capex projects

**Figure**: Daily Bitcoin earned per PH/s over time and as a function of network Hashrate

As of 7/14/2020; historical data since 1/1/2018

Source: BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
Profitability per PH/s falls as Hashrate increases

- We examine the breakeven profitability on a per PH/s basis at current price levels
- The S9 class can mine profitably at current price of $9220 with 1c/kWh cash costs at network Hashrate up to 180 EH/s
- The next gen S19 class of rigs are profitable at Hashrates up to 295EH/s and power prices of 3c/kWh

Figure: Daily Revenue earned and Cash Expense per PH/s as a function of network Hashrate
As of 7/14/2020

Source: BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
BTC Flow / Hashrate relationship in per MWh terms

- Bitcoin earned per MWh falls with increasing Hashrate, and is a function of the power efficiency of the rig generation in use.
- Any mining project must factor in future Hashrate / network power capacity projections in their budget projections.

**Figure:** Bitcoin earned per MWh as a function of network Hashrate

As of 7/14/2020

**Source:** BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
$60 – 105 Revenue / MWh for S17 / S19 class rigs

Revenue per MWh at current 123.85 EH/s Target Hashrate and $9220 Bitcoin price is ~$54 for S17 class equipment, ~$88 for next gen S19 class rigs, but just $25 for older S9 class rigs

Figure: Revenue generated per MWh for different classes of mining rig based on network Hashrate, and BTC price

Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin

As of 7/14/2020

Source: BitOoda estimates, Blockchain.com, Kaiko, Coinmetrics
Hashrate Growth
Constraints:
Price, Power, Production Capacity
$4.5B in 12-month Capex Needed to achieve 260 EH/s

- We assess the installed base of S17 class rigs was ~1.5mm units as of mid-May 2020
- Over the next year, an additional $4.5 billion in capex is needed to add another ~2.3mm rigs to fully utilize the projected 10.6GW of power supply
- While newer S19 / M30 class rigs are preferred, we believe supply constraints will persist through 2020, leading to continuing sales of S17 class rigs

Figure: Bitcoin Hashrate and power consumption
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
Hashrate growth constrains capacity growth

- As Hashrate increases, revenue per PH/s falls, while costs remain the same for a given rig class.
- As a result, internal generation of funds falls, increasing the funding gap over time.
- The price of BTC is thus a critical constraint on the ability of the mining industry to ramp up capacity, as well as on the viability of newly funded projects.
- A second, related constraint is the availability of funding at reasonable terms to close the gap: funding needs are lower if internal generation is higher.
- Absent capital constraints, the next constraint is the capacity of rig manufacturers to deliver the volumes needed to achieve our hash projections.
- Finally, available power capacity is a constraint that sets a (moving) upper limit on rigs in operation. We have modeled a 10% p.a. growth in total available power at viable price points, from an estimated recent maximum available power of 9.6GW.
- We believe semiconductor capacity will prove sufficient to meet demand. Our model assumes delivery volumes that are well within historical norms. At peak, Bitmain alone shipped as many as 2.56 million units in 6 months. However, near term supply constrains remain, including lingering Covid-related supply chain disruptions as well as reported shipment delays at Bitmain related to disagreements among the founders.
- The key constraint we examine here is internal generation and the funding gap.
Revenue / MWh: Hash growth offsets price

- Our conservative model assumes revenue / MWh falls from ~$100 to $60 for S19 class rigs, **even with price appreciating to $19k in 24 months**
- We do not factor in any further average power price declines for the network, but note that both flaring and intermittent / demand response operations are intended to have average power prices far below the network average

*Figure: Revenue and cost per MWh
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin
As of 7/14/2020

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
$4.1 B funding gap
Over next 18 months

- Internal generation for the industry assumes BTC price grows steadily to ~$19k in 2 years, although many industry participants might model a higher price
- Per our model, the Bitcoin mining industry will need $4.1B in external funding to support expansion through the end of 2021
- The ability to raise financing is the second boundary condition limiting Hashrate

**Figure:** Bitcoin network capex and internal generation

Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin
As of 7/14/2020

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
60k Weekly Shipments Achievable: No Capacity Constraint

- Concerns have been raised about the ability of manufacturers to deliver the 60k units per week built into our Hashrate projections
- However, Bitmain filings (IPO prospectus, pp 163) reveal they were able to deliver over 95,000 S9s per week in 2018
- The industry has the ability to ship >150k devices a week, although we believe shipments will likely be lumpy based on wafer deliveries from the foundries

Figure: Bitcoin network capex and internal generation
Note: We assume a PUE of 1.12 to estimate share of power actively used to mine Bitcoin
As of 7/14/2020

Source: BitOoda, Blockchain.com, Kaiko, Coinmetrics
7nm and 5nm should dominate rig shipments through 2022

- The next major step in ASIC technology will come with the ramp up in 5nm technology. At this node, TSMC, the primary supplier to Bitmain, has a lead over Samsung, the other major foundry.
- While TSMC is seeing volume orders at both 7nm and 5nm nodes, their process geometries look similar to Intel’s 10nm node.
- We believe Samsung also features a tighter process geometry, so Samsung is close behind TSMC.
- Samsung recently announced that plans for commercial production on a 3nm process node would likely be delayed into 2022, while 5nm will likely be the mainstay of 2021 production (See this news article).
- We believe the dearth of 3nm capacity and likely initial low yields will lead to 5nm processes being the mainstay of ASIC development and production through 2022.
- Thus S19 class rigs will form the bulk of shipments in the next 24 months, although incremental design improvements could lead to efficiency gains that could be reflected in new model lineups.

### Comparison of Intel’s and TSMC’s Process Technologies

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<thead>
<tr>
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<th>Intel 14nm</th>
<th>Intel 10nm</th>
<th>TSMC 10nm</th>
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**Figure:** Comparison of Intel and TSMC process geometry  
**Source:** [https://www.eetimes.com/intels-10nm-node-past-present-and-future](https://www.eetimes.com/intels-10nm-node-past-present-and-future)
Appendix and Sources
Appendix:  
Select Equipment  
Efficiency Statistics

- New equipment offers superior operating performance with capital and power efficiency gains
- With next generation equipment offering lower cash cost than the old, the price of a new prior generation rig needs to be low enough that the total cost to mine, including depreciation is comparable for both models
- This is what we mean by the “displace” price – the needed price for a rig to be competitive with the newer rig that is displacing it

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<th>Product</th>
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Figure: Select Bitcoin mining rig details
Note: Since 2013

Source: BitOoda, Bitmain, Canaan, MicroBT
Appendix:
Rig Classes based on Efficiency Statistics

- Each generation of mining rigs exhibits similar power efficiency per TH/s across manufacturers.
- Thus, it makes sense to simplify analysis based on “generation” or “class” rather than individually by model.
- We use Bitmain models as a generic for each class of rig.

Source: BitOoda, Bitmain, Canaan, MicroBT, Halong, GMO, AsicMinerValue.com
Much of the most sensitive data came from direct conversations with miners, rig manufacturers, and distributors / resellers as well as hosting data providers. The resulting data was more detailed than publicly available, but shared on condition that no raw data nor any personally identifiable information would be published. We have respected that. Where possible, we also used public sources to further build our overall view of the mining space.

Core Sources:
- Coinmetrics.io
- Kaiko.com
- Blockchair.com
- BTC.com
- Blockchain.com

Company Sources:
- https://www.hiveblockchain.com/projects/overview/
- https://www.linkedin.com/company/minebest/about/
- https://bits2u.com/us.html
- https://www.blockwaresolutions.com/
- https://www.bitmain.com/
- https://www.canaan.io/
- https://www.innosilicon.com/
- https://whatsminer.net/

News Sources:
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