



CoinShares Research

THE BITCOIN MINING NETWORK

*Trends, Average Creation Costs,
Electricity Consumption & Sources*

DECEMBER 2019 UPDATE

The Bitcoin Mining Network

- Trends, Composition, Average Creation Cost,
Electricity Consumption & Sources

Christopher Bendiksen & Samuel Gibbons

CoinShares Research

research@coinshares.co.uk

Note: this white paper is provided subject to acceptance of the conditions contained on page 18.

Abstract

In this report we investigate the geographical distribution, composition, efficiency, electricity consumption and electricity sources of the Bitcoin mining network. We also investigate trends in hashrate, hardware costs, hardware efficiency and marginal creation costs. Among our findings is an estimate that the current market-average, all-in marginal cost of creation, at €4/KWh, 15% non-electricity OPEX and 30-month depreciation schedules, is approximately \$6,300. Please note here that we have increased our headline average depreciation schedule from 18 to 30 months in line with increasing hardware lifespans, and decreased our headline average electricity cost to €4/KWh to reflect increased average access to highly competitive electricity prices. If our estimates are correct, this suggests that, at current bitcoin prices (\$7,300), the average miner is profitable. However, going into the reward halving in the spring of 2020, older gear such as the venerable Antminer S9, which is still widely deployed in the network, will likely be approaching the end of its useful lifetime unless the price of Bitcoin rises dramatically, or indeed if more operators gain access to electricity around or below €1/kWh. Furthermore, we show that Bitcoin mining is mainly located in global regions where there are ample supplies of renewable electricity available. And finally, we calculate an estimate of the renewables penetration in the energy mix powering the Bitcoin mining network at 73%, making Bitcoin mining more renewables-driven than almost every other large-scale industry in the world. Our renewables estimate has marginally dropped since our last report, reflecting increased levels of mining in low-renewables regions such as Kazakhstan. However, we still caution that our location estimates likely have error margins of ±5% and should be considered within that context.

Introduction

In this fourth iteration of our bi-annual mining report we continue our ongoing observations and analysis regarding the state of the Bitcoin mining network. As explained in the previous report, we have now discontinued any explanatory treatment of mining as a concept and are focusing entirely on results. For readers wanting to familiarise themselves with or revisit the fundamentals and economics of the Proof-of-Work (PoW) mining utilised in Bitcoin, we recommend the following sources [1][2][3][4].

Bitcoin's PoW miners continue to dominate the cryptocurrency mining industry both in terms of total revenue and total security spend. According to data from CoinMetrics.io, over the course of 2018, Bitcoin

miners received \$5.5bn in total block rewards, \$5.2bn (94.8%) of which was newly minted coins, and \$284m (5.2%) of which were transaction fees.

At this year's average bitcoin price, fee ratio, and block frequency, miners are on their way to making \$5.4bn in total revenue. Total revenues would then be slightly down from 2018, but significantly up from \$3.4bn in 2017. Total fees however, stand to decrease to \$171m this year (annualised), down from \$284m in 2018 and \$554m in 2017.

In percentage terms this would correspond to a 3.2% fee-to-reward ratio, down from 5.2% in 2018 and a whopping 16.4% in 2017. These drops likely reflect diminished overall transaction demand in the

simultaneous context of increased transaction supply offered by the Segregated Witness block capacity increase.

Network Development

Since our last report of June 2019, the hashrate has nearly doubled, from approximately 50 EH/s to almost 90 EH/s, having peaked at more than 100 EH/s. During this period the Hashrate grew somewhat slower than the 5-year average – a period which roughly corresponds to the start of the ‘industrial era’ of Bitcoin mining – but significantly faster than both preceding 6-month periods [Figure 1].

The combination of strong average Bitcoin prices and availability of more powerful hardware have enabled a huge increase in network hashpower. At the time of our last report, the bitcoin price (~\$8,500) was in the midst of a major recovery off of its cyclical lows (~\$3,000) around the beginning of the year. The price then spiked to almost \$14,000 in July before correcting almost 50% down to ~\$7,300 over the course of the next four months. Since then, the price corrected back to a top of ~\$10,500 before dropping back to a new low of ~\$6,500. At the time of writing (3 December 2019) the price stands at \$7,300.

Simultaneously, over the last year or so, major improvements in mining hardware have made their way into the network in significant numbers. The main players are again Bitmain with their Antminer 15 and 17 series, MicroBT with their Whatsminer 10 and 20 series, and to a somewhat lesser extent, Bitfury with their latest Clarke chipset, Canaan with their Avalon 10-series, Innosilicon with their T3 unit, and Ebang with their E10 model.

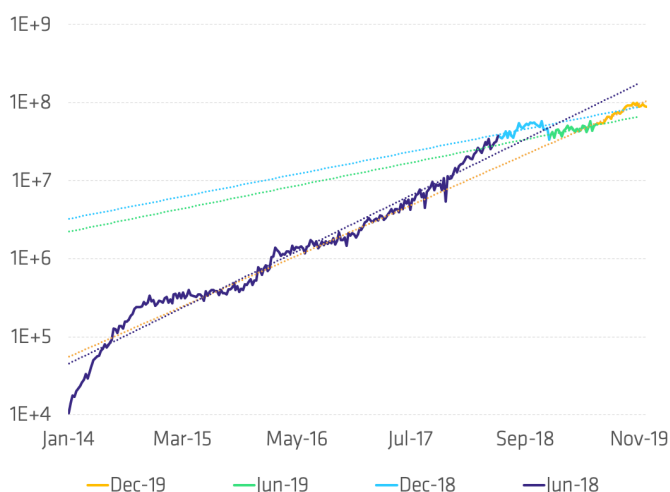
These new models produce as much as 5x the hashrate per unit as their generational predecessors, which means that even though on a unit-basis, several producers report solid sales of previous-generation models, on a hashrate-basis, Bitmain and MicroBT have delivered the vast majority of new capacity to the network.

Unlike the period leading up to our previous report, these last 6 months have been relatively calm in terms of large-scale structural changes. Whereas the period between November 2018 and June 2019 witnessed a large number of bankruptcies and capital transfers, the development of the last 6 months has been mainly one of expansion. What we have seen is some movement of previous-generation hardware to Iran and the establishment of Kazakhstan as a major mining region, but compared to the developments between November 2018 and June 2019, these moves have been relatively small.

More than anything miners have been taking advantage of increased cashflows, especially in spring and summer, from rejuvenated bitcoin prices to reinvest in more powerful and more efficient mining gear – both to secure their share of network hashrate against the advent of next-generation hardware, and as an efficiency preparation for the upcoming block reward halving.

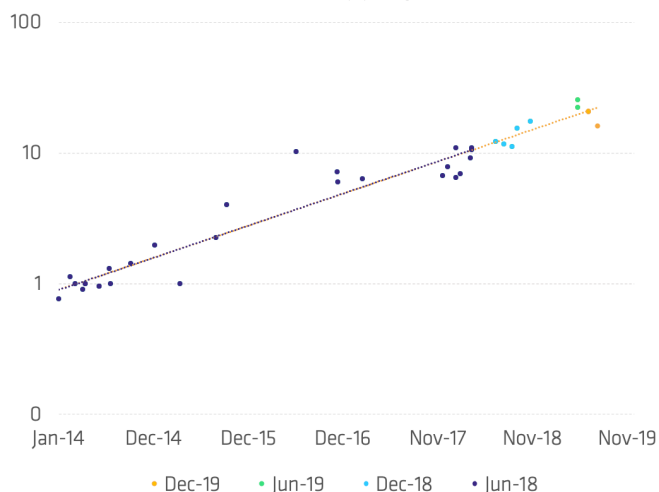
We have reasons to believe the lion’s share of the newly deployed hardware has been predominantly installed in China. There could be many reasons for this, but Occam’s Razor suggests that it is likely an effect of relational and geographic proximity to manufacturers making barriers to business

Figure 1: Total Estimated Bitcoin Hashrate (TH/s)



Sources: Bitcoin Wiki (Dec 2018), CoinShares Research (Dec 2019)

Figure 2: Hardware Efficiency (GH/J) vs Shipping Date



Sources: Bitcoin Wiki (Dec 2018), CoinShares Research (Dec 2019)

comparatively lower. We also understand that it is not uncommon for large Chinese miners to have 'VIP' accounts at the large hardware manufacturers and thereby getting preferential access to the first batches of new gear – although we cannot document this with written proof.

Regardless of the reasons, the effect is that the current Chinese hashrate ratio is likely higher than in June 2019. While we expect this ratio to fall again as latest generation hardware further makes its way into the non-Chinese market, at the time of writing, as much as 65% of Bitcoin hashpower resides within China – the highest we've seen since we began our network monitoring in late 2017.

Hardware Manufacturers

After both having filed for and subsequently cancelled attempts at Hong Kong public listings, both Canaan and Bitmain have yet again entered the IPO market – this time in the United States. Canaan completed their IPO on November 20, raising \$90m at a \$1.33bn valuation. As far as we are aware, there is no specific date set for a potential Bitmain IPO. Nor are there any official figures confirming Bitmain's fundraising goals, but rumours suggest they are aiming between \$300m and \$500m [5].

Successful raises could have significant impacts on the mining manufacturing sector. A fresh capital raise on the order of a hundred million dollars will enable Canaan to improve their balance sheet by repaying short-term debt, and invest significantly in R&D and increased production capacity. This could help bridge the existing gaps in technology and output, both of which have been firmly dominated by Bitmain since the advent of the legendary Antminer S9.

Bitmain, on the other hand, needs fresh inflows of capital mainly to heal a series of self-inflicted wounds caused by poor strategic decisions. Judging from internal leaks and the financial statements released as part of their failed Hong Kong IPO bid, Bitmain has suffered from serial malinvestment, ranging from failed tape-outs, hardware overproduction, over-hiring, and perhaps worst of all, its disastrously performing and likely captive BCH holdings [6][7][8]. All these factors have been contributing to balance sheet issues which, according to a recent leaked internal memo by Bitmain chairman and co-founder Jihan Wu, almost sunk the company in early 2019 [7] [8].

On top of all this, Bitmain's market share has been slipping over the course of the ongoing hardware

replacement cycle. Since our last report in June 2019, we estimate that Bitmain's market share by hashrate has fallen from ~70% to ~66%. To add context, Bitmain's own estimates (via Frost and Sullivan) claim that as recently as in 2017, their market share was around 75% [6].

Legal and Regulation

With the notable exception of Norway, who – given its unique positioning as a cold, well-connected, politically stable country with very cheap power and enormous untapped hydropower potential – should arguably be a mining powerhouse, all free western countries are now benignly or at least non-destructively positioned towards the cryptocurrency mining industry. And after even the Chinese government recently made an apparent 180 on the matter of cryptocurrency mining policy, Norway is left in the rather dubious company of Afghanistan, Pakistan, Algeria, Morocco, Bolivia, Ecuador, Republic of Macedonia, Nepal, Vanuatu, Bangladesh, Venezuela, Vietnam and Saudi Arabia, who populate the list of countries where mining is actively opposed by the state.

The Chinese (at least apparent) policy switch is by far the biggest regulatory development in the mining sector since our last report. From having specifically listed mining, as recently as April [9], as an undesirable industry which should be phased out, this mention was stricken from the November version of the same policy document [10]. In its wake, there have even been opinion pieces written in Sichuan newspapers calling for state subsidies to attract even more miners, an attitude which would seem impossible to field through official Chinese newspapers only a few months back [11].

At least on the face of it, this seems like a welcome development for Chinese miners. However, we remain cautious with regards to CCP apparent acceptance of the industry. Even though Chinese leader Xi Jinping recently announced a national strategic focus on 'blockchain', it has since become abundantly clear that they do not consider actual decentralised cryptocurrencies as part of that strategy [12]. For context, it is worth mentioning that the use of Bitcoin for trading or retail payments remains forbidden in China, and that banks and financial institutions are prohibited from using it for any purpose [13].

Outside of China, the most important remaining mining regions where regulatory status remains unclear is Russia, Iran and Kazakhstan. While large

Table 1 -5: Market-Wide Creation Cost (US\$/BTC) at 15% C&O OPEX and -50% - +50% of Standard CAPEX

-50% CAPEX

+15% C&O OPEX

CAPEX Horizon (Depreciation Schedule)

Electricity OPEX	48 Months	42 Months	36 Months	30 Months	24 Months	18 Months	12 Months
¢1/kWh	1665	1,764	1,896	2,081	2,357	2,819	3,742
¢2/kWh	2639	2,738	2,869	3,054	3,331	3,792	4,715
¢3/kWh	3612	3,711	3,843	4,027	4,304	4,766	5,688
¢4/kWh	4585	4,684	4,816	5,001	5,278	5,739	6,662
¢5/kWh	5559	5,658	5,790	5,974	6,251	6,712	7,635
¢6/kWh	6532	6,631	6,763	6,947	7,224	7,686	8,608
¢7/kWh	7506	7,604	7,736	7,921	8,198	8,659	9,582

Source: CoinShares Research (Dec 2019)

-25% CAPEX

+15% C&O OPEX

CAPEX Horizon (Depreciation Schedule)

Electricity OPEX	48 Months	42 Months	36 Months	30 Months	24 Months	18 Months	12 Months
¢1/kWh	2,011	2,160	2,357	2,634	3,050	3,742	5,126
¢2/kWh	2,985	3,133	3,331	3,608	4,023	4,715	6,099
¢3/kWh	3,958	4,106	4,304	4,581	4,996	5,688	7,072
¢4/kWh	4,932	5,080	5,278	5,554	5,970	6,662	8,046
¢5/kWh	5,905	6,053	6,251	6,528	6,943	7,635	9,019
¢6/kWh	6,878	7,026	7,224	7,501	7,916	8,608	9,993
¢7/kWh	7,852	8,000	8,198	8,474	8,890	9,582	10,966

Source: CoinShares Research (Dec 2019)

Standard CAPEX Assumption

+15% C&O OPEX

CAPEX Horizon (Depreciation Schedule)

Electricity OPEX	48 Months	42 Months	36 Months	30 Months	24 Months	18 Months	12 Months
¢1/kWh	2,357	2,555	2,819	3,188	3,742	4,664	6,510
¢2/kWh	3,331	3,529	3,792	4,161	4,715	5,638	7,483
¢3/kWh	4,304	4,502	4,766	5,135	5,688	6,611	8,457
¢4/kWh	5,278	5,475	5,739	6,108	6,662	7,584	9,430
¢5/kWh	6,251	6,449	6,712	7,081	7,635	8,558	10,403
¢6/kWh	7,224	7,422	7,686	8,055	8,608	9,531	11,377
¢7/kWh	8,198	8,395	8,659	9,028	9,582	10,504	12,350

Source: CoinShares Research (Dec 2019)

+25 CAPEX

+15% C&O OPEX

CAPEX Horizon (Depreciation Schedule)

Electricity OPEX	48 Months	42 Months	36 Months	30 Months	24 Months	18 Months	12 Months
¢1/kWh	2,704	2,951	3,280	3,742	4,434	5,587	7,894
¢2/kWh	3,677	3,924	4,254	4,715	5,407	6,561	8,867
¢3/kWh	4,650	4,897	5,227	5,688	6,380	7,534	9,841
¢4/kWh	5,624	5,871	6,200	6,662	7,354	8,507	10,814
¢5/kWh	6,597	6,844	7,174	7,635	8,327	9,481	11,787
¢6/kWh	7,570	7,817	8,147	8,608	9,300	10,454	12,761
¢7/kWh	8,544	8,791	9,120	9,582	10,274	11,427	13,734

Source: CoinShares Research (Dec 2019)

+50 CAPEX

+15% C&O OPEX

CAPEX Horizon (Depreciation Schedule)

Electricity OPEX	48 Months	42 Months	36 Months	30 Months	24 Months	18 Months	12 Months
¢1/kWh	3,050	3,346	3,742	4,295	5,126	6,510	9,278
¢2/kWh	4,023	4,320	4,715	5,269	6,099	7,483	10,252
¢3/kWh	4,996	5,293	5,688	6,242	7,072	8,457	11,225
¢4/kWh	5,970	6,266	6,662	7,215	8,046	9,430	12,198
¢5/kWh	6,943	7,240	7,635	8,189	9,019	10,403	13,172
¢6/kWh	7,916	8,213	8,608	9,162	9,993	11,377	14,145
¢7/kWh	8,890	9,186	9,582	10,135	10,966	12,350	15,118

Source: CoinShares Research (Dec 2019)

scale mining does happen in Iran, authorities have been observed implementing increasingly more draconian measures to limit or control miners [14]. In Russia and Kazakhstan, trading Bitcoin remains prohibited, but mining seems to be at the very least tolerated and in certain cases even encouraged. This highlights the sometimes-conflicting interests between internal power factions in certain countries, e.g. between central banks seeking to limit or prohibit Bitcoin use, and power utilities seeking to monetise excess power resources.

Average All-In Creation Cost (ROI Breakeven Level)

As is customary we calculate and present our current estimates of market-wide average creation costs [Tables 1 – 5]. Please note that this time around, due to increasing lifespans of mining hardware, we have moved the average middle-point of our depreciation horizon column from 18 to 30 months. Our current headline estimate at $\text{€}4/\text{kWh}$ and 30-month capex depreciation now stands at approximately $\$6,100$ [Table 3]. As was also evident in our previous report, we see that certain segments of miners—particularly those with that highly coveted combination of very cheap electricity ($<\text{€}3/\text{kWh}$) and brand new next-generation gear (potentially enabling depreciation over as much as 3-4 years) are able to mine Bitcoin at less than $\$4,000$ [Table 3]. This combination of circumstances becomes even more powerful if the miner can get preferential or simply well-timed pricing on their mining gear, such as miner-manufacturers or existing VIP clients. For a more detailed discussion of our modelling methodology, please see page 4 of our May 2018 report [15].

At current bitcoin prices, we believe the overall mining industry is profitable on average, with both previous-generation hardware – though only at relatively cheap electricity costs ($<\text{€}3/\text{kWh}$) – and next-generation hardware, even at relatively expensive electricity costs ($>\text{€}5/\text{kWh}$), currently able to generate a positive ROI [Figure 3].

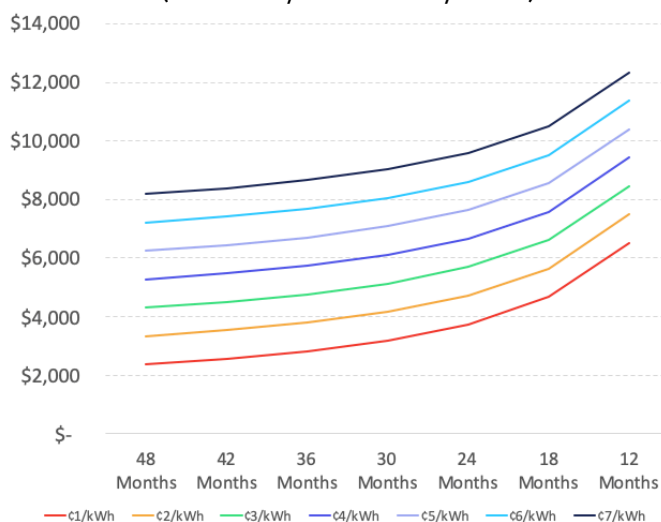
Overall, the capex component of the total mining cost has increased as a result of the large amount of hardware investment over the last six months. On an apples-to-apples basis, the capex ratio of total cost at $\text{€}5/\text{kWh}$ and 18-month depreciation schedule has increased from 38% in June 2019, to 44% at the time of writing. However, as mentioned above, the general increase in hardware lifespan has caused us to increase our headline average depreciation horizon from 18 to 30 months. Current cost components are broken down by capex depreciation horizon in Table 7.

Average Cashflow Breakeven Levels

The other important cost level to consider is the cashflow breakeven level. As we have detailed in our previous work [15], this level is critical for estimating the price level below which the average miner would have to start shutting down their mining equipment. While ROI breakeven levels are also important, sustained prices below ROI breakeven levels only wipe out miner capital, causing changes in industry ownership ratios over time. Prices below cashflow breakeven levels, on the other hand, cause immediate hashrate reductions.

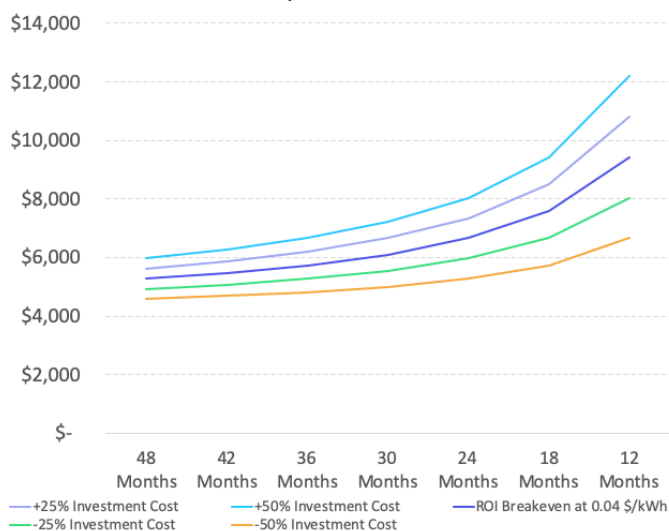
Our estimate for the current market-average cashflow breakeven at $\text{€}4/\text{kWh}$ and 15% additional C&O Opex is

Figure 3: All-in ROI Breakeven at 15% C&O OPEX vs CAPEX Horizon (Sensitivity to Electricity OPEX)



Source: CoinShares Research (Dec 2019)

Figure 4: All-in ROI Breakeven at $\text{€}4/\text{kWh}$ & 15% C&O OPEX Versus CAPEX Horizon (Sensitivity to Total CAPEX)



Source: CoinShares Research (Dec 2019)

Table 6: Market-Wide Average Cashflow Breakeven Levels (Electricity OPEX vs C&O OPEX)

Electricity OPEX	Additional Cooling & Other (C&O) OPEX				
	5%	10%	15%	20%	25%
¢1/kWh	889	931	973	1,016	1,058
¢2/kWh	1,777	1,862	1,947	2,031	2,116
¢3/kWh	2,666	2,793	2,920	3,047	3,174
¢4/kWh	3,555	3,724	3,893	4,063	4,232
¢5/kWh	4,444	4,655	4,867	5,078	5,290
¢6/kWh	5,332	5,586	5,840	6,094	6,348
¢7/kWh	6,221	6,517	6,813	7,110	7,406

Source: CoinShares Research (Dec 2019)

\$3,900. We caution here though, that our model operates on the basis of hashrate, not difficulty, meaning that it will tend to overestimate cash (and ROI) costs in times of hashrate growth and underestimate it in times of hashrate reduction.

Electricity Draw

As of the time of writing, we estimate the total electricity draw of the entire Bitcoin mining industry to be approximately 6.7 GW. This is a 43% increase from June 2019 levels even though we've adjusted our cooling average further down to 5% (which might still be too high). On an annualised basis, we currently estimate that the network draws approximately 61 TWh. To put that into industrial context, the global aluminium smelting industry uses approximately 900 TWh per year (based on global annual production of 63.2 Mt and an electricity draw of 14 MWh/t [16][17]).

It is again worth repeating here that as a general principle, the Bitcoin mining network will consume as much electricity as the market is willing to sell it in return for the total value of the block reward (new coins plus fees), minus a competitive margin. This means that increasing the efficiency of mining gear has no impact on the total electricity draw of the network, it can only increase the hashrate per unit of electricity consumed. Over the long term, it is only the value of the block reward and the cost of available electricity that can impact the network's total power draw.

Geographical Distribution of Miners

Bitcoin miners are fairly well distributed across the globe [Figure 5], however they do have a significant tendency to cluster into certain similar geographies. Looking more closely at their distribution, it is clear that they are predominantly – by volume weight – confined to technologically advanced, relatively sparsely populated, hilly or mountainous regions traversed by powerful rivers.

Among these regions we find the major mining centres of: Washington and New York States in the United States; British Columbia, Alberta, Newfoundland & Labrador, and Quebec Provinces of Canada; Iceland; Northern Scandinavia (Norway and Sweden); The Caucasus (Georgia and Armenia); the Siberian Federal District of Russia; Yunnan – and most importantly of all regions, Sichuan – provinces of China. There are also minor mining centres found in similar geographies such as Austria, Montana in the United States, and Guizhou Province in China.

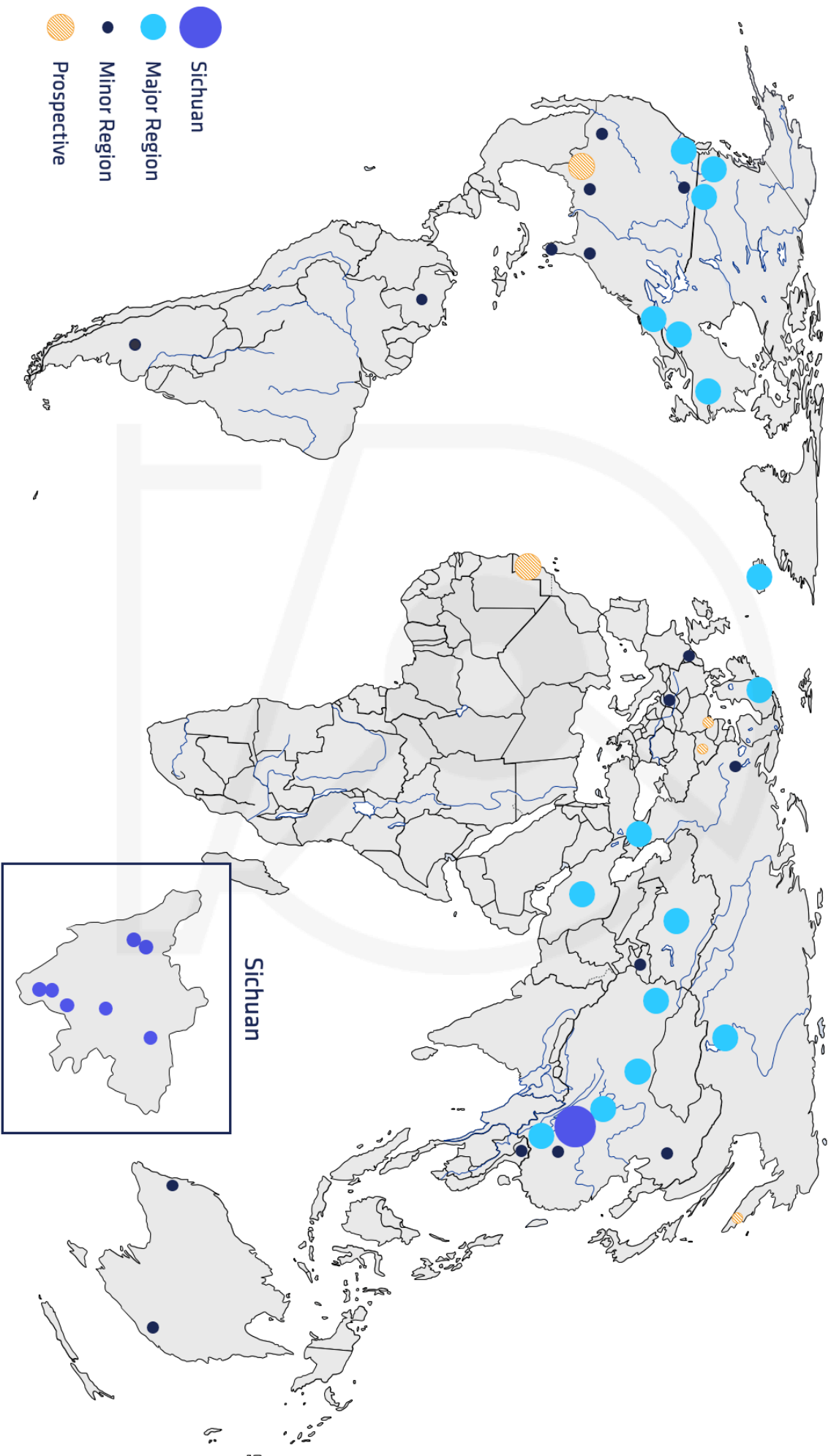
The remaining major mining regions which do not fit into the above geographical mould are Iran, Kazakhstan, and Xinjiang and Inner Mongolia provinces of China. Minor mining regions where the above described geography does not (or where we cannot be certain that it does) fit the above description include: Florida, Texas and Arizona in the United States; Western Australia and New South Wales states of Australia; Belgium; Belarus; the North

Table 7: Mining Cost Component Breakdown by Capex Horizon at ¢4/kWh

	CAPEX Horizon (Depreciation Schedule)						
	48 Months	42 Months	36 Months	30 Months	24 Months	18 Months	12 Months
Electricity OPEX	64%	62%	59%	55%	51%	45%	36%
CAPEX	26%	29%	32%	36%	42%	49%	59%
Cooling & Other OPEX	10%	9%	9%	8%	8%	7%	5%

Source: CoinShares Research (Dec 2019)

Figure 5: Global Overview of Bitcoin Mining Regions. Regions With Large Relevant Regions Shown in Teal, Sichuan in Blue and Remaining Minor Regions in Black



Circles do not show relative scale of mining facilities

[18][19][20][21][22][23][24][25][26][27][28][29][30][31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][53][54][55][56][57][58][59][60][61][62][63][64][65][66][67][68]

Table 7: Chinese Renewables Penetration by Province

Relevant Chinese Provinces	Renewables Penetration
Sichuan (2017)	90%
Yunnan (2017)	92%
Inner Mongolia (2017)	16%
Xinjiang (2017)	23%
Average ex. Sichuan	44%

Source: Morgan Stanley Research (Oct 2018)

West Federal District of Russia; Argentina; and Venezuela. See map for list of sources.

Energy Mix

Building on our increasing visibility of the mining industry as a whole, we continue our ongoing reporting on the likely energy mix of the input electricity in the mining industry. Again, we refer back to our previous reports – in this case page 5 of our November 2018 report [69] – for a more detailed discussion of the methodology and background of the investigation. For more casual readers, however, we summarise our methodology in simplified terms below.

Our main assumption is that miners, wherever they are located, utilise the same mix of power generation (fossil/nuclear or renewable) as the average reported in their region. This is a conservative estimate in our opinion as we know anecdotally that large numbers of miners in otherwise fossil/nuclear-dominated regions, such as New York State and Texas, actually use renewable power. Conversely however, we also know anecdotally that miners in Kazakhstan – where there does exist a small amount of renewable energy – are all mining on coal.

We then estimate the total percentage of hashrate residing in each relevant region, down to the lowest administrative subdivision for which reports of energy mix are available. This means state/provincial-level for Canada, the US, China and Russia, and country level for all other relevant regions.

Finally, we multiply the percentage of renewables penetration in each relevant mining region with our estimate of the percentage of the total global mining industry residing in that region. We then arrive at a global weighted average estimate of renewables

Table 8: Non-Chinese Renewables Penetration by Country, State or Province

Relevant Non-Chinese Countries/States/Provinces	Renewables Penetration
Washington (2016)	92%
New York (2016)	45%
Alberta (2018)	11%
British Columbia (2018)	98%
Quebec (2018)	100%
Newfoundland and Labrador (2018)	95%
Norway (2016)	99%
Sweden (2016)	65%
Iceland (2016)	100%
Kazakhstan (2017)	12%
Iran (2017)	0%
Siberian Federal District (2015)	44%
Armenia (2017)	33%
Georgia (2016)	79%
Average	62%
Rest of the World (2016)	18%

Sources: EIA (Nov 2018), R2E2 (Jul 2017), Rosstat (2015) Natural Resources Canada (Sep 2018), SATBA (Feb 2017)

penetration in the Bitcoin mining network's total energy generation [Tables 7 - 9].

From the previous section (*Geographical Distribution of Miners*) readers will note that we divided the geographical clusters of Bitcoin miners into two main baskets. We refer to the first basket as the hydro regions and the second basket as the non-hydro regions. The hydro regions, as implied by the name, are global regions of hydro-power abundance.

In the remaining regions we observe a mix of fossil, nuclear, solar and wind generation sources, with some, such as Iran dominated by natural gas, and others, such as Kazakhstan, Xinjiang and Inner Mongolia, dominated by coal and supplemented with small amounts of wind or hydro. While there exist miners using solar as their main power source, such operations are still relatively rare.

We currently estimate that 65% of global mining happens in China, and that Sichuan alone produces 54% of global hashrate, with the remaining 11% split more or less evenly between Yunnan, Xinjiang and Inner Mongolia. We arrived at this latest estimate by

Table 9: Breakdown of Global Renewables Penetration in Bitcoin Mining

Region	Global Mining Share	Renewables Penetration	Share of Renewables for Mining	Share of Fossil/Nuclear for Mining
Sichuan	54%	90%	48%	5%
Relevant Remaining China	11%	44%	5%	6%
Relevant Non-Chinese Regions	31%	62%	19%	12%
Rest of World	4%	18%	1%	4%
Global Total	100%		73%	27%

Sources: Morgan Stanley Research (Oct 2018), EIA (Nov 2018), Natural Resources Canada (Sep 2018), R2E2 (Jul 2017), SATBA (Feb 2017), CoinShares Research (May 2019)

starting with an average from our mining database of 4-1 Sichuan-to-Non-Sichuan Chinese mining distribution. Next, we estimate that 70% of newly deployed hashrate since our last report has gone to China and 30% to the remaining non-Chinese mining regions.

Our estimate for Sichuan's dominance within both China and the world is marginally lower this time than in our last report. We attribute this change mainly to increased visibility on our part. Inasmuch as we were expecting to see some seasonal movement out of Sichuan due to the end of the wet season, reliable evidence of such nomadic movement has not materialised among our sources this year.

Out of the remaining 35% of miners, we estimate that 31% of global hashrate production is evenly split between Washington, New York, British Columbia, Alberta, Quebec, Newfoundland and Labrador, Iceland, Norway, Sweden, the Siberian Federal District of Russia, Kazakhstan, Georgia and Iran. The last 4% is assumed to be distributed widely enough that the global average energy mix is a good enough fit to estimate their energy sources. These estimates and the corresponding regional renewables penetrations are summarised in Table 9.

Using the above methodology, we arrive at a new estimate of 73% renewables penetration in the mining energy mix. The renewables estimate is marginally down from 74% in our June 2019 report and again reflects both increased visibility of the industry on our part as well as movements within the industry. Major trends this time around has been significant flows of S9-generation hardware to non-renewable-dominated regions such as Iran and Kazakhstan, although this trend has been offset by the majority of newly added latest-generation gear being deployed in Sichuan.

Caveats and Uncertainty Factors

It is necessary at this point to caveat that while we do our utmost to accurately pinpoint the location of global mining centres, the Bitcoin mining industry remains a highly private and secretive industry. As a result, our estimates may be subject to significant potential uncertainty. We believe that our database of global mining centres has around 70% total visibility on the overall market, and we cross-reference all our model results against this database in order to quality-check our assumptions.

While we have made no attempt to formally quantify our uncertainly levels, we intuitively guesstimate that, e.g. our geographical location estimates might be $\pm 5\%$ uncertain, and that our renewables penetration figures should be taken to include a tentative uncertainty of around $\pm 5\%$.

That being said, we confidently consider our numbers to be amongst the best available in the industry. For other estimates using survey-based methodologies we refer readers to the following sources [70][71].

In addition to these caveats, we should also keep in mind the cyclical nomadism of many Chinese miners. As we've discussed in our previous reports [69][72], seasonal changes in electricity prices, particularly in Sichuan, causes miners to migrate between Sichuan in the wet season (roughly late spring to late fall) and Inner Mongolia and Xinjiang in the dry season (roughly winter and early spring). The current timing of our papers makes these intra-year flows difficult to pin down which could cause an overestimation of renewables penetration.

Conclusion

The Bitcoin mining network continues to develop along its five-year trend-lines on metrics of efficiency

increase and hashrate growth.

This latest period has been one of healthy bitcoin prices and large-scale expansion of the network's total hashpower through next-generation hardware. We believe most of this expanded capacity has been deployed in China, but expect new gear to steadily make its way into the non-Chinese markets over time and equalising the geographical deployment ratios.

Miners are still majorly confined to regions dominated by cheap hydro-power, such as Scandinavia, The Caucasus, The Pacific North West, Eastern Canada and Southwestern China. We believe this to be a direct consequence of the extremely low electricity prices available in these regions, especially where the hydro-power is relatively under-utilised. However, we are observing increased movement into coal-dominated regions such as Kazakhstan, and Texas has also re-emerged as a major prospective mining region after some previous set-backs.

Finally, using a combination of estimates of global mining locations and regional renewables penetrations we again calculate the Bitcoin mining industry to be heavily renewables-driven. Our current approximate percentage of renewable power generation in the Bitcoin mining energy mix stands at 73%, around four times the global average.

Overall, our findings reaffirm our view that Bitcoin mining is acting as a global electricity buyer of last resort and therefore tends to cluster around comparatively under-utilised renewables infrastructure. This could help turn loss making renewables projects profitable and in time – as the industry matures and settles as permanent in the public eye – could act as a driver of new renewables developments in locations that were previously uneconomical.

Appendix

Specific Assumptions

(CoinShares Research Assumption Rating Strength from 0 – 10)

Mining Unit Cost in US\$

All unit prices are attempts at volume weighted averages across the entire hardware life cycle.

These assumptions are broadly based on the same information as those in our May report. Wherever updates were necessary, explanations have been added in brackets below the original assumptions.

Bitfily:

US\$ 899 – 8/10

This is sourced from the BitcoinTalk overview of

currently competitive hardware [Steamtyme, "BitcoinTalk," 7 October 2018. [Online]. Available: <https://bitcointalk.org/index.php?topic=5045732>]. The price is pulled from the website of the retailer at the last time available. Therefore, we are quite confident this at least accurately represents the retail price even if it does not capture the second-hand prices. For less popular miners such as this there are not enough second-hand sales to get a good idea of secondary market pricing. Bitfury Block Box:

US\$ 1,300,000 – 6/10

This is a composite estimate from private conversations with Bitfury where we simply take the average of their two options, with and without immersion cooling.

Private Bitfury Facilities:

US\$ 400,000 – 4/10

This assumption is an order of proportionally scaling Song's Bitmain supply cost [J. Song, "Medium," 14 April 2017. [Online]. Available: <https://medium.com/@jimmysong/just-how-profitable-is-bitmain-a9df82c761a>] onto Bitfury and then doubling the per-chip cost to reflect higher costs of the full set up and the higher production costs suggested by the lower success of Bitfury relative to Bitmain.

Bitfury Tardis:

US\$ 5,070 – 6/10

The Bitfury Tardis does not have information available from the retailer, however, from other people that have inquired we understand that the price is dependent on the amount of hashboards and efficiency one prefers. The upper bound – the price we use – is \$5,070. This is a Tardis assembled using 'Clarke' chips using 8 chipboards doing about 78 TH/s at \$65 per TH/s. Thus, the machine is assumed to cost 78 * 65 which is 5,070. The most efficient machine but with the least hashrate is a Tardis assembled with the same chips but using only 5 hashboards. It comes out at 66 TH/s and the price is \$55 per TH/s thus for this machine you get 66 * 55 = 3,630. To be conservative we assume the miners are operating more firepower trading off efficiency, even if we don't think this is necessarily the case as they are likely to optimise and even reconfigure in operation.

Bitfury x Hut 8:

US\$ 1,300,000 – 6/10

See above assumption for privately sold Bitfury units.

Antminer S7:

US\$ 1,500 – 3/10

It is very hard to update the price of this assumption so we have simply scaled down the certainty. With prices

at the time of writing it is assumed some people have turned these back on.

Antminer S9 Publicly Available Units:

US\$ 390 - 6/10

In China, 1,000 yuan was frequently cited by miners, read in interviews and on forums, blogs and social media platforms. We also discovered a lot that larger mines can get for as low as 700 or 800 yuan and we also heard from a particular source in the West they were as low as 150 USD. Sources are Mr Nasser, <https://bihu.com/article/1905931713> (Yu Wei, the former head of a Bitmain mine) and Liu Feng (a miner connected enough to be amongst the first miners to find preferential rates in Iran). <http://www.xingliancaijing.com/blockchain/chainnews/10758.html>

Some miners will have held on to their miner since their original investment. So, we took there to be roughly 2,000,000 S9 and assume 75% of them have changed hands. We took a weighted average across the four data points we have: i) the price from our previous report, ii) the price we believe was wholesale for Western mines, iii) the price we heard most frequently from Chinese sources and iv) the price we heard for wholesale amongst Chinese miners.

25% @ November's 1,100 weighted average - 1,100 USD

25% @ Ray Nasser, Telegrams and say other Western prices reported (would wait on you to see what you hear from friends you said you would ask) - 200 USD

25% @ Yu Wei, former head of Bitmain Mine says 1,000 yuan, roughly - 150 USD

25% @ Liu Feng, well connected miner says on average 750 yuan, roughly 110 USD

Taking the average returns \$390

[November 2019 Update: We did not observe that many S9 changing hands from May/June period such that the price needed changing. Most miners had their S9s to hand for the rainy season or in cheaper fossil fuel regions like Kazakhstan or Iran. Since we've assumed not many have changed hands but obviously some small amount has, the strength of the assumption has been dropped by 1.]

Antminer S9 Private Bitmain Facilities:

US\$ 500 - 7/10

Here we base the assumption on an article by Jimmy Song entitled "Just how profitable is Bitmain?" [J. Song, "Medium," 14 April 2017. [Online]. Available: <https://medium.com/@jimmysong/just-how-profitable-is-bitmain-a9df82c761a>.]

[Update November 2018: We do not believe Bitmain have added any more S9's to their private facilities since May.]

Antminer S15 Private Bitmain Facilities:

US\$ 500 - 7/10

At the time of writing this unit has not yet began shipping to the public even though payment has been taken both domestically on their Chinese e-shop and on the international website. The estimate is based on a similar ratio of the retail price compared to the price that Song calculated in his article "Just how profitable is Bitmain?" [J. Song, "Medium," 14 April 2017. [Online]. Available: <https://medium.com/@jimmysong/just-how-profitable-is-bitmain-a9df82c761a>.]. While we appreciate that 7nm chips are more expensive than 16nm chips, we also believe Bitmain have unlocked significant economies of scale since their first introduction of the S9.

Antminer S17 Private Bitmain Facilities:

US\$ 500 - 6/10

The estimate is based on a similar ratio of the retail price compared to the price that Song calculated in his article "Just how profitable is Bitmain?" [J. Song, "Medium," 14 April 2017. [Online]. Available: <https://medium.com/@jimmysong/just-how-profitable-is-bitmain-a9df82c761a>.]. While we appreciate that 7nm chips are more expensive than 16nm chips, we also believe Bitmain have unlocked significant economies of scale since their first introduction of the S9.

Antminer S17:

US\$ 2,500 - 8/10

At this point Bitmain has a lot of big customers who will get group deals less than the price advertised on their website. We also know that many buyers are very savvy and use the Bitmain coupon scheme which often lowers the price. One thing to note is that US customers do not often suffer the 'Trump tax' and so this price is representative of their purchases as Bitmain currently ship this gear out of Malaysia.

Avalon 841:

US\$ 415 - 7/10

Assuming the officially stated price is accurate.

[Update November 2018: We have been unable to find any new price information as previous information was taken from Chinese sources. This is significant because the vast majority of Canaan's customers are domestic; previously it has been as high 99.6% yet as of 2017 it still remains as high as 91.5% [Canaan Inc., "HKEX News," 2018. [Online]. Available: <http://www.hkexnews.hk/APP/SEHK/2018/2018051401/Documents/SEHK201805150005.pdf>.]. We therefore assume the price to be the same as our previous estimate.]

Avalon 921:

US\$ 742 – 7/10

Assuming the officially stated price is accurate.

[Update November 2018: We have been unable to find any new price information as previous information was taken from Chinese sources. This is significant because the vast majority of Canaan's customers are domestic; previously it has been as high as 99.6% yet as of 2017 it still remains as high as 91.5% [Canaan Inc., "HKEX News," 2018. [Online]. Available: <http://www.hkexnews.hk/APP/SEHK/2018/2018051401/Documents/SEHK201805150005.pdf>]. We therefore assume the price to be the same as our previous estimate.]

Avalon 1041:

US\$ 1,070 – 9/10

This is the price listed for sale on their website. Considering Canaan has MOQ quite high on their website, it's plausible that discounts on this price are not so readily available.

Ebang E10:

US\$ 1800 – 7/10

This is sourced from the BitcoinTalk overview of currently competitive hardware [Steamtyme, "BitcoinTalk," 7 October 2018. [Online]. Available: <https://bitcointalk.org/index.php?topic=5045732.0>]. The price is pulled from the website of the retailer at the last time available. Therefore, we are quite confident this at least accurately represents the retail price even if it does not capture the second-hand prices. For less popular miners such as this there are not enough second-hand sales to get a good idea of secondary market pricing.

GMO Mining B2/B3:

US\$ 1,999 – 9/10

This price is listed on their website [GMO Miner, "GMO Miner," 2018. [Online]. Available: <https://gmominer.z.com/en/pricing/>].

DragonMint T1:

US\$ 1,199 – 7/10

This assumption is based on the price of batch 1. We know of no further batches but have seen a lot of people exchanging these for lower prices and so have altered the price down to reflect this as we believe there are not a lot of them around that second-hand market is heavily indicative of the actual price as there's little evidence of any large-scale miners using these. This is also to match the price on the BitcoinTalk.org.

Innosilicon T2 Turbo:

US\$ 1,350 – 7/10

This is sourced from the BitcoinTalk overview of currently competitive hardware [Steamtyme, "BitcoinTalk," 7 October 2018. [Online]. Available: <https://bitcointalk.org/index.php?topic=5045732.0>]. The price is pulled from the website of the retailer at the last time available. Therefore, we are quite confident this at least accurately represents the retail price even if it does not capture the second-hand prices. For less popular miners such as this there are not enough second-hand sales to get a good idea of secondary market pricing.

Innosilicon T3 Turbo:

US\$ 2,000 – 8/10

This was the price of the miner at the time of writing, but it is in stiff competition with Bitmain prices and so fluctuation occurs frequently.

MicroBT's Whatsminer M10:

US\$ 1,441 – 7/10

This is sourced from the BitcoinTalk overview of currently competitive hardware [Steamtyme, "BitcoinTalk," 7 October 2018. [Online]. Available: <https://bitcointalk.org/index.php?topic=5045732.0>]. The price is pulled from the website of the retailer at the last time available. Therefore, we are quite confident this at least accurately represents the retail price even if it does not capture the second-hand prices. For less popular miners such as this there are not enough second-hand sales to get a good idea of secondary market pricing.

Total Mining Units

Bitfily:

1,000 – 3/10

This estimate is low because the amount of information available is equally small. We therefore have little to no information about sales. Having said that, considering the mediocre specifications of this hardware there is nothing to indicate this unit has sold much more than 1,000 copies.

Bitfury Block Box:

448 – 4/10

Here we use market estimates of approximately 12% of total hashrate (28 exahash) as stated by the CEO of Bitfury to reverse-arrive at 448 by using stated efficiency figures.

[Update November 2018: We have carried the assumption over but scaled the assumptions certainty down by a factor of one to reflect the inevitable decrease in certainty as time passes from the last data point.]

Private Bitfury Facilities:

112 – 6/10

This assumption is reverse calculated from Bitfury investor presentations stating 132 megawatts and subtracting off the known 'Hut 8' units leaving Bitfury's own facilities.

[Update November 2018: This figure has just been brought forward but knocked down a point as Bitfury have released a new chip and sold some Block Boxes publicly and thus presumably a few privately as well.]

Bitfury Tardis:

1,000 – 5/10

The Bitfury Tardis is a very new miner with their new 'Clarke' chips and so it is assumed very few have been sold so far. The only sale we know of is the aforementioned one to Hut 8.

Bitfury x Hut 8:

85 – 10/10

This information is available to us by email from Hut 8 and as a publicly listed company we have strong reason to believe this is entirely accurate.

Antminer S7 Series:

1,000 – 5/10

We have assumed a certain small amount of these miners has come back online considering price of bitcoin at the time of writing. However, these miners are few and far between where the operator essentially has access to nearly free electricity. For example, Upstream Data.

Antminer S9 Publicly Available Units:

1,700,000 – 7/10

Bitmain's S9 and other very similar hardware from Bitmain (T9's and all other versions of the S9) are widely assumed by many mining experts and large scale miners to be the vast majority of the network at about 2/3 of all miners in their efficiency class.

[Update May 2019: Previously I had estimated about 1,950,000 S9 machines were in use privately. Mao Shing, founder of the F2Pool [one of the largest in the world], thinks between 600,000 and 800,000 mines have been turned off. Given the kind of mine that would be turned off is around this level of efficiency and the prolific role of the S9 in this bracket, I took the average and removed that from the figure of S9's operating.

*The speaker says that amount fell off in November, so we take it off the highest figure but given the new price levels and lagging difficulty it's possible for miners to be making good profits at 7 cents even. <https://www.zilian8.com/130015.html>.

(<https://bitcointalk.org/index.php?topic=5091665.msg51107675#msg51107675>) Thus we have assumed that at least half of the S9's that were taken off due to price levels have been fired back up. Another 130,000 have been added see below 'S9 Private'.]

[Update November 2019: More miners have found cheaper power that has enabled people to maintain and power on these less efficient models. Our own research, observations in mines and connections have confirmed the fact that a lot of S9s are still mining]

Antminer S9 Private Bitmain Facilities:

100,000 – 7/10

Here we base our assumption on remarks from Bitmain employees and interviews from Quartz articles on Bitmain (<https://qz.com/search/bitmain>, all worth reading) and Chinese news sources covering Bitmain. The Chinese sources suggest that the mine in Xinjiang is 'three times' the size of the Ordos mine of 25,000 machines; that the Xinjiang mine and the Sichuan and Yunnan mines have a migratory cycle based on the abundance of wind and solar in the dry season (Xinjiang, Northwest) [M. Jiansheng, "China Smart Grid," 8 March 2017. [Online]. Available: <http://www.chinasmartgrid.com.cn/news/20170308/622441.shtml>.] [kidneybeans, "Bitcoin86," 12 January 2018. [Online]. Available: <http://www.bitcoin86.com/wk/19509.html>.] and the hydropower of Sichuan and Yunnan in the rainy season (Southwest) [M. Jiansheng, "China Smart Grid," 8 March 2017. [Online]. Available: <http://www.chinasmartgrid.com.cn/news/20170308/622441.shtml>.]; and lastly that they have facilities like it elsewhere in China and the world (such as in Anhui and Newfoundland [R. Antle, "CBC," 27 April 2017. [Online]. Available: <https://www.cbc.ca/news/canada/newfoundland-labrador/great-north-data-bitmain-technologies-lawsuit-1.4084925>.])].

[Update November 2018: This figure has been brought forward despite Bitmain's assumed making and selling of units. Their IPO documents state that their private mining operations are limited [BitMain Technologies Holding Company, "HKEX News," October 2018. [Online]. Available: <http://www.hkexnews.hk/APP/SEHK/2018/2018092406/Documents/SEHK201809260017.pdf>.] and we have therefore assumed no additional gear added.

Update May 2019: This figure has reduced by 130,000 as Bitmain have taken 130,000 offline including having made a sale of 100,000 or more. They have been added to the mining S9's as a result. (<https://www.jinse.com/blockchain/364841.html>)

Antminer S15 Private Bitmain Facilities:

120,000 – 5/10

Although this miner has only just been announced it is well known that Bitmain does not mind mining on gear before it is released to the public and so we have assumed that it has a significant amount of these mining already.

[Update May 2019 According to Coindesk and multiple Chinese sources 200,000 Bitmain miners have been deployed. They are potentially all S17 since they are for themselves to mine with and so it's likely they gave themselves the best gear, but for now, as its an assumption already, we have split them across both models evenly. There are 20,000 extra S15 in D15 as we had previously assumed 20,000 of this model had already been deployed. <https://www.coindesk.com/bitmain-bitcoin-mining-farms-antminer>, <http://www.elecfans.com/emb/dsp/20190325890024.html>]

Antminer S17 Private Bitmain Facilities:

125,000 – 5/10

According to Coindesk and multiple Chinese sources 200,000 Bitmain miners have been deployed. They are potentially all S17 since they are for themselves to mine with and so it's likely they gave themselves the best gear, but for now, as its an assumption already, we have split them across both models evenly. There are 20,000 extra S15 in D15 as we had previously assumed 20,000 of this model had already been deployed.

<https://www.coindesk.com/bitmain-bitcoin-mining-farms-antminer>, <http://www.elecfans.com/emb/dsp/20190325890024.html>

[Update November 2019: There has been a lot of internal strife in Bitmain and both their employees and competitors have suggested that their production has not been going as planned and so we have assumed only a small increase in the number of miners they have self-mining]

Antminer S17

400,000 – 3/10

There has been some S15 and S17 shipped we assume but we do not know anything much about figures yet.

[Update November 2019: Same as the above assumption. Bitmain has not been able to produce as many new miners as they would like and the market has not been as receptive to buying them either as there is a lot of uncertainty in miners minds approaching the halving. <https://www.8btc.com/article/509934>]

Avalon 7-series

5/10 - We have assumed a certain small amount of these miners has come back online considering the price of bitcoin at the time of writing. Of course, this only applies to particular locations where electricity rates meet the needs of miners like in Canada or China. It would be assumed most of these remain in China and so are being used in the hydro-centric areas of Sichuan and neighboring provinces.

Avalon 821, 841:

468,500* – 6/10

This is estimated from extrapolating inferred production runs given the reports of total amount of hardware sold in Canaan's IPO application [Canaan Inc., "HKEX News," 2018. [Online]. Available: <http://www.hkexnews.hk/APP/SEHK/2018/2018051401/Documents/SEHK201805150005.pdf>].

[Update November 2019: These numbers are found in here: <http://www.bitcoin86.com/wk/48288.html>]

Avalon 921:

163,000 – 8/10

This is estimated from extrapolating inferred production runs given the reports of total amount of hardware sold in Canaan's IPO application [Canaan Inc., "HKEX News," 2018. [Online]. Available: <http://www.hkexnews.hk/APP/SEHK/2018/2018051401/Documents/SEHK201805150005.pdf>].

[Update November 2019: These numbers are found in here: <http://www.bitcoin86.com/wk/48288.html>]

Avalon 1041

57,000 – 9/10

These numbers are found in here: <http://www.bitcoin86.com/wk/48288.html>

Ebang E10:

200,000 – 6/10

This is an estimate back-calculated from the percentage of hardware claimed by Ebang to be produced in 2017 and carried forward. This figure is independently calculated by a company commissioned to do the work for their IPO application [<http://www.hkexnews.hk/APP/SEHK/2018/2018062101/Documents/SEHK201806240005.pdf>, "HKEX News," 2018. [Online]. Available: <http://www.hkexnews.hk/APP/SEHK/2018/2018062101/Documents/SEHK201806240005.pdf>.] and they expect that Ebang accounted for 11% of hardware produced in 2017. This

is mentioned on various occasions, first on page 1. The reason we do not consider it entirely reliable is that as we have seen little evidence of a market share of that magnitude, and that the report supporting the IPO application documents was commissioned by Ebang themselves.

GMO Mining B2/B3:

16,000 - 8/10

As with the previous estimate for GMO we are grateful for their transparency and from multiple public documents their aggregate number of machines deduced from their total hashrate and the efficiency of their hardware.

DragonMint T1:

25,000 - 3/10

We have low confidence in this figure but we wanted to include an estimate nevertheless. There was a widespread need for a Bitmain competitor and in anticipating this, miners bought up all of the Halong mining products unseen and with a minimum order size of 5 units. At such a small batch size estimate the figure has minimal impact on overall calculations.

Innosilicon T2 Turbo:

10,000 - 3/10

As with the other smaller companies it is very hard to gather much information to make a reliable estimate as to the number of miners out there.

Innosilicon T3 Turbo:

10,000 - 3/10

As with the other smaller companies it is very hard to gather much information to make a reliable estimate as to the number of miners out there.

MicroBT's Whatsminer M10:

105,000 - 6/10

As with the other smaller companies it is very hard to gather much information to make a reliable estimate as to the number of miners out there. However, the efficiency of this miner is very impressive for its release date and there is significant forum support. Therefore, we have assumed they have put out a maximum output due to the community response.

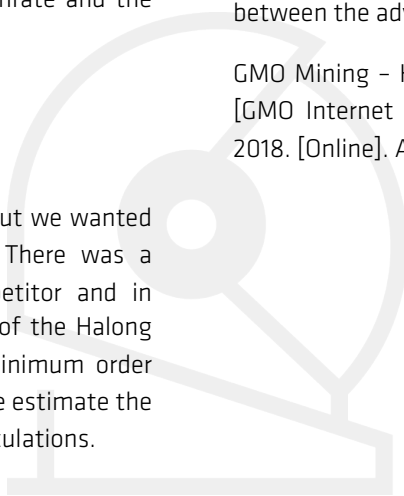
[Update November 2019: Dr Yang, the CEO of Whatsminer, revealed just how many miners they had been putting out in a speech found here: <http://www.gs265.com/archives/41786>]

Hashrates and Power Efficiency per Unit

All except GMO Mining - 9/10

This represents a tempered belief in the state of the producers which will have modified only slightly if we believe the real-life specs are different (e.g. reading published reviews or forum reviews of trusted members acknowledging there to be a large disparity between the advertised spec and the testing spec).

GMO Mining - Hashrates taken from company filings [GMO Internet Group, "GMO Cryptocurrency Mining," 2018. [Online]. Available: <https://mining.gmo.jp/en/>].



Works Cited

1. **Bendiksen, Christopher and Gibbons, Samuel.** The Bitcoin Mining Network. *CoinShares*. [Online] May 21, 2018. <https://coinsharesgroup.com/research/bitcoin-mining-network-june-2018>.
2. **Wikipedia.** Proof of Work. *Wikipedia*. [Online] https://en.wikipedia.org/wiki/Proof_of_work.
3. **Wiki, Bitcoin.** Proof of Work. *Bitcoin Wiki*. [Online] https://en.bitcoin.it/wiki/Proof_of_work.
4. **Bendiksen, Christopher.** Beware of Lazy Research. *Medium*. [Online] Dec 2018. <https://medium.com/coinshares/beware-of-lazy-research-c828c900b7d5>.
5. **Perez, Yessi Bello.** TheNextWeb. *Bitmain quietly filed for a US IPO with Deutsche Bank as its sponsor*. [Online] Oct 2019. <https://thenextweb.com/hardfork/2019/10/30/cryptocurrency-mining-manufacturer-bitmain-reportedly-filed-for-a-us-ipo-with-deutsche-bank-as-its-sponsor/>.
6. **Bitmain.** Bitmain Prospectus. *Originally HKEX*. [Online] <http://templatelab.com/bitmain-ipo-prospectus/>.
7. **Chong, Nick.** Ousted Bitmain CEO Micree Zhan fires back. *Cryptoslate*. [Online] Nov 2019. <https://cryptoslate.com/ousted-bitmain-ceo-micree-zhan-fires-back-at-jihan-wu-looks-to-retake-the-firm/>.
8. **Peng, Liu.** The founder ousted another founder. *Finance Sina*. [Online] Oct 2019. <http://finance.sina.com.cn/roll/2019-10-30/doc-iicezuev5848295.shtml>.
9. **Goh, Branda and John, Alun.** China wants to ban bitcoin mining, traders say move not a surprise. *Reuters*. [Online] April 2019. <https://uk.reuters.com/article/uk-china-cryptocurrency/china-wants-to-ban-bitcoin-mining-traders-say-move-not-a-surprise-idUKKCN1RLOC7>.
10. **Liang, Hong.** Heavy policy adjustment: NDRC "eliminates industries" deletes "virtual currency mining". *Chain Finance*. [Online] Nov 2019. <http://liancaijing.com/651956.html/comment-page-9>.
11. **Chenglin, Yuan.** Accelerate the development of the Chengdu-Chongqing region into a new national development pole. *Sichuan Daily*. [Online] October 2019. <https://epaper.scdaily.cn/shtml/scrb/20191028/225880.shtml>.
12. **Kolakowski, Mark.** How China is Fueling 25% Bitcoin Rally Amid Trade War. *Investopedia*. [Online] Nov 2019. <https://www.investopedia.com/how-china-is-fueling-25-bitcoin-rally-amid-trade-war-4774465>.
13. **Zhang, Laney.** Regulation of Cryptocurrency Around the World. *Library of Congress*. [Online] Jun 2018. <https://www.loc.gov/law/help/cryptocurrency/world-survey.php>.
14. **Bitcoin86.** Iran rewards people for exposing illegal use of subsidized power mining. *Bitcoin86*. [Online] Nov 2019. <http://www.bitcoin86.com/wk/48509.html>.
15. **Bendiksen, Christopher and Gibbons, Samuel.** The Bitcoin Mining Network. *CoinShares Research*. [Online] May 2018. <https://coinsharesgroup.com/research/bitcoin-mining-network-june-2018>.
16. **World Aluminium.** Primary Aluminium Smelting Energy Intensity. *World Aluminium*. [Online] Jul 2019. <http://www.world-aluminium.org/statistics/primary-aluminium-smelting-energy-intensity/#data>.
17. **World Aluminium.** Primary Aluminium Production. *World Aluminium*. [Online] Nov 2019. <http://www.world-aluminium.org/statistics/#data>.
18. **Arminers.** [Online] <https://arminers.com/>.
19. **Gogo, Jeffrey.** \$50 Million Bitcoin Mining Farm Opens in Armenia. *News.bitcoin*. [Online] Oct 2018. <https://news.bitcoin.com/50-million-bitcoin-mining-farm-opens-in-armenia/>.
20. **Haig, Samuel.** 20MW Solar Farm Set to Power Crypto Mining in Rural Australia. *News.bitcoin*. [Online] Apr 2018. <https://news.bitcoin.com/20mw-solar-farm-set-to-power-crypto-mining-in-rural-australia/>.
21. **HydroMiner.** [Online] <https://www.hydominer.org/>.
22. **Coin Factory.** [Online] <https://www.coin-factory.at/>.
23. **MiningConf.** Top 10 Mining Farms. *MiningCong*. [Online] 2019. <https://miningconf.org/index.php?app=index&mod=Index&act=votes>.
24. **Argo.** ArgoBlockchain. [Online] <https://argoblockchain.com/about-us/facilities/>.
25. **Hut8.** Operations. [Online] <https://hut8mining.com/operations>.
26. **Sockoloons.** Large Scale Hosting Facilities Available. *CoinForum*. [Online] 2018. <https://coinforum.ca/discussion/5155/large-scale-hosting-facilities-available>.
27. **DMG Blockchain.** [Online] <https://dmgblockchain.com/>.
28. **Antle, Rob.** Bitmain Legal Dispute. *cbc*. [Online] Apr 2017. <https://www.cbc.ca/news/canada/newfoundland-labrador/great-north-data-bitmain-technologies-lawsuit-1.4084925>.
29. **Bitfarms.** [Online] <https://www.bitfarms.com/#operations>.
30. **T, Carl.** Chinese Firm Huatie HengAn. *Bitcoin Exchange Guide*. [Online] Apr 2019. <https://bitcoinexchangeguide.com/chinese-firm-huatie-hengan-losses-23-million-in-its-secret-crypto-mining-business/>.
31. **Redman, Jamie.** Study: Publicly Listed Chinese Firms Quietly Participate in Bitcoin Mining. *News.Bitcoin*. [Online] May 2019. <https://news.bitcoin.com/study-publicly-listed-chinese-firms-quietly-participate-in-bitcoin-mining/>.
32. **31QU.** The Flood Season is Coming. *8btc*. [Online] Jan 2019. <https://www.8btc.com/article/349247>.
33. **Planet Daily.** Decisive Battle in the Flood Season. *8btc*. [Online] Feb 2019. <https://www.8btc.com/article/359114>.
34. **Bitcoin86.** The Mining Journey in 2019. [Online] Feb 2019. <http://www.bitcoin86.com/wk/35735.html>.
35. **GS265.** Is the Flood Season a miner's lifeline? [Online] Mar 2019. <http://www.gs265.com/archives/10816>.
36. **ChainNews.** Miners Rush to Buy Second-Hand Mining Machinery. *ChainNews*. [Online] Mar 2019. <http://liancaijing.com/405440.html>.
37. **Bitcoin86.** Mining Machine Nandu. *Bitcoin86*. [Online] Feb 2019. <http://www.bitcoin86.com/wk/36208.html>.
38. **8btc.** The Flood Season Is Coming. *8btc*. [Online] Jan 2019. <https://www.8btc.com/article/349247>.
39. **RHY.** [Online] <https://www.rhy.com/>.

40. **World Bank Group.** Cryptocurrencies and Blockchain. *worldbank*. [Online] May 2018. <http://documents.worldbank.org/curated/en/293821525702130886/pdf/Cryptocurrencies-and-blockchain.pdf>.
41. **Alderman, Liz.** *NyTimes*. *Despite Bitcoin's Dive, a Former Soviet Republic Is Still Betting Big on It*. [Online] Jan 2019. <https://www.nytimes.com/2019/01/22/business/georgia-bitcoin-blockchain-bitfury.html>.
42. **Moonlite.** [Online] <https://www.moonlite.io/>.
43. **Genesis Mining.** [Online] <https://www.genesis-mining.com/>.
44. **Hive Blockchain.** *Hive*. *Hive*. [Online] <https://www.hiveblockchain.com/projects/>.
45. **Bitcoin86.** After approval of cryptocurrency mining, Iran will become a global 'mining paradise'? *Bitcoin86*. [Online] Jul 2019. <http://www.bitcoin86.com/wk/42922.html>.
46. **Unknown.** Iran Crypto Miners Scramble. *BunnyPub*. [Online] Jul 2019. <https://www.bunnypub.net/en/crypto/topics/120895>.
47. **8btc.** Mining Army Sweeps through Iran. *8btc*. [Online] Jan 2019. <https://www.8btc.com/article/351712>.
48. **Teng, Lylian.** Chinese Bitcoin Miners Suffer in Iran Despite Cheap Power. *BitcoinMagazine*. [Online] Apr 2019. <https://bitcoinmagazine.com/articles/chinese-bitcoin-miners-suffer-iran-despite-cheap-power/>.
49. **NrMine.** [Online] <https://www.nrmine.com/>.
50. **GMO Miner.** [Online] <https://gmominer.z.com/en/>.
51. **MiningCity.** [Online] <https://miningcity.com/news>.
52. **MineBest.** [Online] <https://minebest.com/about-us/>.
53. **AkiPress.** [Online] Sep 2019. <https://akipress.com/news:625581>.
54. **Kabar.** [Online] Aug 2019. <http://kabar.kg/news/me-kr-predlagaet-sposob-nalogooblozheniia-maining-ferm-v-biudzheth-budut-postupat-bolee-300-mln-somov-v-god/>.
55. **Northern Bitcoin.** [Online] <https://northernbitcoin.com/>.
56. **Marinoff, Nick.** *BitcoinMagazine*. *BitcoinMagazine*. [Online] Mar 2018. <https://bitcoinmagazine.com/articles/bitfury-expands-norway-35-million-bitcoin-data-center/>.
57. **Baydakova, Anna.** Bitcoin Mining Farms are Flourishing on the Ruins of Soviet Industry. *CoinDesk*. [Online] Sep 2019. <https://www.coindesk.com/bitcoin-mining-farms-are-flourishing-on-the-ruins-of-soviet-industry-in-siberia>.
58. -. Inside a Siberian Crypto Mining Complex. *CoinDesk*. [Online] Sep 2019. <https://www.coindesk.com/watch-inside-a-siberian-crypto-mining-complex>.
59. **Akolkar, Bhushan.** Russia's Leningrad Region Unveils the Largest Crypto Mining Farm. *Bitcoinist*. [Online] Aug 2018. <https://bitcoinist.com/russias-leningrad-region-unveils-the-largest-crypto-mining-farm/>.
60. **Jiwo.** The Capital of Russian Mining. *Jiwo*. [Online] Oct 2018. <https://jiwo.ru/stolica-rossiyskogo-mayninga-irkutsk>.
61. **Madison Group.** [Online] <https://www.madison-group.com.hk/about-us>.
62. **Hive.** Hive Blockchain completes acquisition of Kolos Norway. *HiveBlockchain*. [Online] May 2018. <https://www.hiveblockchain.com/news/hive-blockchain-completes-acquisition-of-kolos-norway-as/>.
63. **Sweans.** [Online] <https://www.sweans.com/mining/>.
64. **Parks, Lisa.** Sounds of a Bitcoin Data Center in Montana. *GlobalMedia*. [Online] Jan 2019. <http://globalmedia.mit.edu/2019/01/13/sounds-of-a-bitcoin-data-center-in-montana/>.
65. **Salcido.** Inside a Bitcoin Mine. *SalcidoEnterprises*. [Online] Aug 2018. <https://www.salcidoenterprises.tech/news/2018/4/27/inside-a-bitcoin-mine>.
66. **Plattsburgh BTC.** [Online] <https://plattsburghbtc.com/>.
67. **CoinMint.** World's Largest Digital Currency Data Centre Commences Operations. *prsnwswire*. [Online] Jun 2018. <https://www.prnewswire.com/news-releases/worlds-largest-digital-currency-data-center-commences-operations-300659812.html>.
68. **Helms, Kevin.** Vietnam to Import More Mining Rigs. *News.Bitcoin*. [Online] Jan 2018. <https://news.bitcoin.com/vietnam-imported-mining-rigs/>.
69. **Bendiksen, Christopher and Gibbons, Samuel** The Bitcoin Mining Network. *CoinShares Research* [Online] Nov 2018. <https://coinsharesgroup.com/assets/resources/Research/bitcoin-mining-network-november-2018.pdf>.
70. **Hileman, Garrick and Rauchs, Michel.** Global Cryptoasset Benchmarking Study. *Cambridge Centre for Alternative Finance* [Online] Nov 2017. https://www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/alternative-finance/downloads/2017-global-cryptocurrency-benchmarking-study.pdf.
71. **Rauchs, Michel, et al.** 2nd Global Cryptoasset Benchmarking Study. *Cambridge Centre for Alternative Finance* [Online] Dec 2018. https://www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/alternative-finance/downloads/2018-12-ccaf-2nd-global-cryptoasset-benchmarking.pdf.
72. **Bendiksen, Christopher and Gibbons, Samuel** The Bitcoin Mining Network. *CoinShares Research* [Online] Jun 2019. <https://coinsharesgroup.com/assets/resources/Research/bitcoin-mining-network-june-2019.pdf>.

Important Disclaimer

Please note that this document is provided on the basis that the recipient accepts the following conditions relating to provision of the same (including on behalf of their respective organisation). Should the following conditions not be acceptable, please destroy this document without retaining any copies.

This document does not contain, or purport to be, financial promotion(s) of any kind. This document does not contain reference to any of the investment products or services offered by members of the CoinShares Group.

Digital assets and related technologies can be extremely complicated. Crypto-currencies can be extremely volatile and subject to rapid fluctuations in price, positively or negatively. Cryptocurrencies are loosely regulated and there is no central marketplace for currency exchange. Supply is determined by a computer code, not by a central bank, and prices can be extremely volatile. The digital sector has spawned concepts and nomenclature much of which is novel and can be difficult for even technically savvy individuals to thoroughly comprehend. The sector also evolves rapidly.

With increasing media attention on digital assets and related technologies, many of the concepts associated therewith (and the terms used to encapsulate them) are more likely to be encountered outside of the digital space. Although a term may become relatively well-known and in a relatively short timeframe, there is a danger that misunderstandings and misconceptions can take root relating to precisely what the concept behind the given term is.

The purpose of this document is to provide objective, educational and interesting commentary and analysis in connection with the cryptocurrency market. This document is not directed at any particular person or group of persons. This material is solely for informational purposes and shall not constitute an offer to sell or the solicitation to buy securities. Although produced with reasonable care and skill, no representation should be taken as having been given that this document is an exhaustive analysis of all of the considerations which its subject-matter may give rise to. This document fairly represents the opinions and sentiments of CoinShares (Jersey) Limited ("CSJL"), which is the issuer of this document, as at the date of its issuance but it should be noted that such opinions and sentiments may be revised from time to time, for example in light of experience and further developments, and this document may not necessarily be updated to reflect the same.

The information presented in this document has been developed internally and/or obtained from sources believed to be reliable; however, the CoinShares Group does not guarantee the accuracy, adequacy or completeness of such information. Predictions, opinions and other information contained in this document are subject to change continually and without notice of any kind and may no longer be true after the date indicated. Any forward-looking statements speak only as of the date they are made, and the CoinShares Group assumes no duty to, and does not undertake, to update forward-looking statements. Forward-looking statements are subject to numerous assumptions, risks and uncertainties, which change over time.

Nothing within this document constitutes (or should be construed as being) investment, legal, tax or other advice. This document should not be used as the basis for any investment decision(s) which a reader thereof may be considering. Any potential investor in digital assets, even if experienced and affluent, is strongly recommended to seek independent financial advice upon the merits of the same in the context of their own unique circumstances.

CoinShares (Jersey) Limited ("CSJL"), a private limited company incorporated in Jersey, Channel Islands (#102184), is regulated by the Jersey Financial Services Commission in the conduct of AIF Services Business and certain classes of Fund Service Business and Investment Business pursuant to the Financial Services (Jersey) Law 1998, as amended. The registered office address of CSJL is 2 Hill Street, St. Helier, JE2 4UA, Channel Islands. CoinShares Capital LLC, Member FINRA. The registered office address of CoinShares Capital LLC is 101 Fifth Avenue, Suite 605, 6th Floor, New York, NY 10003, USA.

The CoinShares Astronaut is a trademark and service mark of CoinShares (Holdings) Limited.

Copyright © 2019 CoinShares Group. All rights reserved. Use and reproduction of this document or any parts thereof may be done without permission, however, the following citation should accompany any reference to or other use of the information contained in this document: The Bitcoin Mining Network—Trends, Average Creation Cost, Electricity Consumption & Sources. Available at www.coinshares.co.uk/research.

