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North American Bitcoin Mining Index (NABMI)

A comprehensive analysis of the companies, capital, and energy mix powering Bitcoin mining in North America

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By John Lee Quigley

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Foreword

North America is emerging as a serious contender to house the largest Bitcoin mining industry in the world. China has historically been home to the dominant share of the industry with hashrate production and mining pools heavily concentrated in the region. Their dominance has been partly driven by their control of Bitcoin ASIC manufacturing. Chinese miners have historically benefited from shorter delivery times and preferential access to hardware, but the dynamics of the global industry are shifting.

Compass Mining's dive into the growth of the Bitcoin mining industry in North America highlights that miners are placing greater emphasis on jurisdictional certainty, long-term access to inexpensive power prices, and the opportunity to establish operations that can be competitive for multiple decades. They are willing to forgo the advantages of preferential hardware delivery times to set up structures that they believe can give them a sustainable competitive advantage in an industry where inefficiency rarely survives. The narrative that China could potentially influence Bitcoin may therefore naturally subside if China's relative dominance over mining declines with the growth of the North American Bitcoin mining industry.

Several trends and natural competitive advantages suggest that North America will continue to increase its total hashrate and may eventually compete with China for the largest share of global network hashrate. As Bitcoin continues to permeate through our society, we are noticing a clear corresponding increase in talent and innovators entering the Bitcoin ecosystem. Within Fidelity's Center for Applied Technology (FCAT), we are optimistic about North American mining partly because of this surge in passionate talent dedicating their talent to its growth. We are already witnessing the results through impactful innovations across energy infrastructure, financial instruments, and technology aimed specifically at helping miners grow.

Energy tends to be the most costly and perhaps the most important input for miners. While the average energy price is still higher for North American miners than miners in the Asia-Pacific, the United States and Canada are rich with both fossil fuels and renewable energy sources, providing significant opportunities to entrepreneurial mining operators. At scale, large miners can source globally competitive electricity rates for hundreds of megawatts of capacity. At a smaller scale, promising young companies are democratizing and decentralizing mining by bringing energy producers into the industry through deployments of shipping-container-style mobile "data centers" at points of wasted or stranded energy. There is potential for scale here, as the U.S.'s 2019 output of 538 billion cubic feet of vented and flared natural gas could alone power all North American miners many times over [1]. These young companies are creating solutions to manage energy loads that simultaneously increase revenues by monetizing surplus energy, reduce waste, and provide a more reliable energy supply for down-stream consumers.

North America's energy supply is a strong natural advantage, but North America's biggest competitive edge could be its robust capital markets. North American miners have access to unmatched quantities of capital that have facilitated hundreds of millions of dollars in hardware purchases. Estimates suggest North American miners have purchased at least $500 million in hardware over the last year, which may be conservative as it only accounts for the public announcements [2]. This flow of capital into the industry is critical since Chinese miners have a competitive edge in their ability to acquire hardware at a lower price point than their North American counterparts. As institutional investors allocate more capital towards Bitcoin mining, there is also a greater need for sophisticated risk management strategies. Although we are still early, the financialization of mining is a clear trend, and we are already seeing innovation in derivatives and other investment

products that are evolving from early-stage concepts to live products with real volumes. The assurance to capital allocators that familiar risk management products and strategies are becoming available may increase their willingness to invest in the space.

Despite accelerating growth, the North American mining industry still faces challenges. Hardware procurement is among the greatest challenges for miners globally, but it is of particular concern to North American miners who are geographically isolated from points of production in Asia and must add import costs onto the hardware price. This is among the most significant barriers to achieving greater geographic hashrate dispersion. North America is far behind Chinese ASIC manufacturers and catching up would require substantial capital and time. Although this Compass report outlines reasons to be optimistic about the state of hardware procurement in North America, this challenge will likely persist for many years.

Apart from hardware, and despite the impressive growth I've mentioned, there are also still many physical and network infrastructure needs. It is not until quite recently, for example, that North American miners had the option to contribute hashrate to institutional-quality pools based in North America. Until American pools can compete in size with those in China, it is likely that narratives of China's control over Bitcoin will persist. Furthermore, although North American energy infrastructure is a strong competitive advantage, we are still in the early days of tapping into its potential to support miners. It is time-intensive to build facilities that can support hundreds of megawatts of capacity, so even those receiving funding today may not come online for years.

There is good reason to be optimistic about the future of Bitcoin mining in North America. Unfortunately, much of the information on the state of mining in North America is still misrepresented, fragmented, and incomplete. The following report from Compass covers the trends I have mentioned above and more, providing the most comprehensive overview of Bitcoin mining in North America to date. Reports like these are critical to educating a largely uninformed public about the current state of mining in the West and North America's opportunity to challenge the incumbents. Turning what has traditionally been an opaque and walled-off industry into one that is transparent and accessible is critical to the industry's maturation, and Compass is among the leaders in driving towards that end. We at the Fidelity Center for Applied Technology thank Compass for contributing such strong research to the public and hope that reports like these will become more common in a dynamic and promising industry.

— Brian Wright, Director, Bitcoin Mining
Fidelity Center for Applied Technology

Introduction

The dominant share of the Bitcoin mining market has resided in China since its genesis in 2013. All mass-scale Bitcoin ASIC hardware manufacturers are based in China while Bitcoin mining service providers and Bitcoin mining pools are also heavily concentrated in the country. Recent estimates place China's share of hashrate production between 40% and 60% [4].

The landscape is changing though as North America's Bitcoin mining ecosystem continues to grow at a fast pace. Not only are pure-play miners bringing more hashrate onshore but service providers, mining pools, and startups with innovative concepts are all emerging with the imperative of establishing long-term operations in North America.

This report explores the evolving nature of the Bitcoin mining industry and how North America, and the US in particular, are positioning themselves to become the leading Bitcoin mining industry. We will analyze the key factors underpinning the growth in the US Bitcoin mining industry and also consider developments that have changed the favorability of mining in China. We will also review the Bitcoin mining industry in Canada and the relative tradeoffs of mining in the country. The study is split into three chapters.

This report does not include research on the state of Bitcoin mining operations in Mexico or other Latin American nations, due to the relative youthfulness of mining markets in those areas compared to both the US and Canada. They are a favorable choice for future research, particularly given recent attention in El Salvador.

Chapter 1 details the Bitcoin mining industry in the US. The chapter includes an overview of some of the main players in the US ecosystem and highlights the recent trend towards Bitcoin mining becoming a more institutionalized activity in the US. Significant sections are dedicated to understanding the country's capital markets and electricity markets and how they pertain to Bitcoin miners. The Texas ERCOT market is closely examined and we consider the effective power prices that miners can secure by participating in demand-response programs in this market. A significant section is also dedicated to understanding the conditions US miners face when procuring hardware.

Chapter 2 considers whether the US Bitcoin mining industry can grow to the same scale as the Chinese Bitcoin mining industry. This chapter will provide further detail on China's historic dominance in the mining industry while also highlighting its previous dominance of bitcoin-fiat trading volume. Hardware has been a defining factor that has maintained China's foothold over the Bitcoin mining industry. We dedicate the majority of this chapter to analyzing how the Bitcoin ASIC manufacturing industry has evolved historically and how it is likely to change moving forward. We consider how these changes impact the relative advantages of mining in the US compared to China. We also consider factors like weather seasonality and the impact on power prices, data center buildout costs, and jurisdictional certainty.

Chapter 3 details the Bitcoin mining industry in Canada, an industry that burgeoned earlier than the US and is home to a mixture of cryptocurrency-related companies. Canadian miners have the possibility to secure some of the most attractive power prices across North America but also face a more bureaucratic regulatory environment that can restrict scalability and impose additional costs. Before presenting the three chapters, we will outline how the study was carried out in the methodology section.

Methodology and Future Research

The North American Bitcoin Mining Index study consisted of the following research activities: (1) An exploration process where the research question that the report aimed to address was determined. This was mainly determined through a mixture of online research, discussions with fellow researchers, and discussions with industry professionals, (2) A collection of unstructured phone interviews with industry professionals who are active in the North American Bitcoin mining industry. (3) A literature review to assess the current information available on the Bitcoin mining industry in North America. The literature review further served to corroborate or refute the information retrieved during the interview process. (4) Independent data analysis. Analysis was carried out on third-party data to draw further insights. (5) Peer review. The final document was forwarded to individuals for critique and input.

Seventeen industry professionals were interviewed as part of the research process. Each conversation lasted roughly one hour and was unstructured. Before each interview, research was carried out on the interviewee and prospective questions were drawn. Interviewees were primarily founders and C-level executives of North American mining-related companies. The interviewees included professionals from companies with activities related to proprietary mining, mining pools, infrastructure, financial services, and energy. One professional was interviewed twice and one professional was interviewed four times to clarify and expand upon certain areas. Notes were taken during the interview, and these notes, combined with the literature review, formed the primary basis for this report's information. No specific quotes were included from the interviews. Any quotes included in the research report were referenced from publicly available sources.

A thorough literature review was conducted which provided independent information for the report. The literature review further served to corroborate or refute information retrieved during the interview process. Over 1500 sources from media outlets, press releases, government agencies, previous research studies, social media posts, and interviews were examined during this process.

Data analysis was carried out on: (i) the relationship between Bitcoin price and the secondary market hardware prices of both latest-generation and old-generation mining equipment, (ii) the historical size of the annualized block subsidy market. Data for hardware prices was sourced from hashrateindex.com while the Bitcoin price data was sourced from the daily closing price of the BitMEX perpetual Bitcoin contract [5]. The BitMEX perpetual Bitcoin contract was used because its price is derived from the price of several Bitcoin spot exchanges, giving a more representative indication of the broader Bitcoin market, compared to a single exchange which can be subject to instances of illiquidity [6]. The correlation between hardware prices and Bitcoin price along with the associated graphs were derived from Google Sheets. The graph associated with the historic size of the annualized block subsidy market was generated in a Jupyter Notebook using the Python Plotly library.

The final draft of the study was forwarded to colleagues, industry professionals, researchers, and other individuals familiar with the Bitcoin mining industry for critique and feedback. Several suggestions were made during this process and the research report was appropriately adjusted.

Chapter 1
The United States Bitcoin Mining Industry

Several factors foster favorable conditions for mining in the US, leading many industry professionals to anticipate that it is only a matter of time before the US claims the largest share of hashrate production. Having the biggest capital markets in the world have played a considerable role in the growth of the US Bitcoin mining industry. The capital raising ability of US companies has allowed them to compete intensely for a limited share of hardware supply coming on to the market. Hardware is the key constraint facing miners globally. Upon establishing competitive cost structures, it is an imperative of miners to maximise their output. However, hardware limits the ability to expand. We will detail the dynamics of the hardware market and how it has evolved since the early stages of the industry.

A complex but abundant power market has provided opportunities to procure extremely low-cost energy that can place US miners among the lowest-cost miners in the industry. The Texas market is among the most attractive regions for miners securing low-cost energy and it is anticipated that a power law will form where the majority of hashrate production is generated within these regions. Chapter 1 will discuss all of these factors in further detail and present an overview of the current advantages and disadvantages facing US Bitcoin miners.

Growth of Bitcoin Mining in the United States, Infrastructure Play, Jurisdictional Certainty, and Institutional Presence

Data suggests that the US mining industry has recorded a phase of immense growth since September 2019 [7, 8]. This growth is corroborated by a growing institutional presence. Entities like Fidelity Center for Applied Technology (FCAT), Galaxy Digital, and Digital Currency Group are among the institutions that have established operations in the United States Bitcoin mining industry. Several mining-focused companies have publicly listed in the United States and companies are emerging with a focus on providing various services to the industry.

US Regulatory Developments

Recent regulatory developments in the United States indicate an increased interest in blockchain technology from the US government. The Office of the Comptroller of the Currency (OCC) issued several interpretive letters that have elucidated how banks can interact with the technology. These letters have served to clarify the following:

- Banks can custody cryptocurrencies and stablecoins (Interpretive Letter #1170) [11].

- Banks can treat blockchains as a settlement infrastructure. Banks can use stablecoins to facilitate payments on behalf of customers (Interpretive Letter #1174) [12].

"INVNs [Independent Node Verification Network] and related stablecoins represent new technological means of carrying out bank-permissible payment activities. We therefore conclude that a bank may validate, store, and record payment transactions by serving as a node on an INVN. Likewise, a bank may use INVNs and related stablecoins to carry out permissible payment activities." (Interpretive Letter #1174, OCC)

In December 2020, a proposal by the US Treasury near the end of the Trump administration attempted to secure oversight into the Bitcoin network, similar to the oversight that is exercised in the banking sector. The Financial Crimes Enforcement Network (FinCEN), a department within the US Treasury, sought to impose know-your-customer (KYC) requirements on cryptocurrency exchanges for transactions relating to self-hosted wallets [13]. Specifically, the rule would require carrying out KYC on self-hosted wallets and would require exchanges to store data for transactions greater than $3,000. For transactions greater

than $10,000, the rule would require exchanges to report the information to FinCEN. The rules would give FinCEN similar oversight to what they exercise in the bank sector through the Bank Secrecy Act (BSA). The proposal received backlash from entities operating in the industry for several reasons. Onerous reporting requirements and privacy infringement concerns were among the critiques. Square and Coinbase were among the companies that criticized the proposal. The proposal was discontinued under the Biden administration.

While comments from the US government specifically related to Bitcoin mining are sparse, Brian Brooks, Former Acting Comptroller of the Currency at the OCC, stated in an interview that the United States faced a "geo-strategic competitiveness" issue due to the large share of mining infrastructure residing in China [14]. Such sentiment combined with the entry of large-scale institutions into the United States industry, and their respective tax dollars, place Bitcoin mining firmly in the interests of the US government. We will likely observe greater commentary on the industry from government authorities in the proceeding years.

High Degree of Jurisdictional Certainty

One of the factors driving a migration of hashrate to the US is a high degree of confidence in how jurisdictions will treat the Bitcoin mining industry. Harry Sudock, VP of Strategy at Griid Infrastructure, noted "jurisdictional certainty" as one of the key variables providing favorable conditions for mining in the US [15]. Sudock elaborated that clarity surrounding tax treatment, energy treatment, and tariff regimes helps make the US a region where multi-decade businesses can be established. In contrast, miners operating in China face much more uncertain jurisdictional conditions. Chinese miners have been noted to operate in a "legal grey area, with large differences in treatment between local jurisdictions" [16]. It has been noted in the literature as early as November 2018 that Chinese miners were either leaving the country or choosing not to reinvest in domestic operations. On a separate occasion, Sudock commented that Chinese miners "do not live under a stable regulatory regime" [4].

This view has been corroborated by recent developments in China's Inner Mongolia region. On February 25th, Inner Mongolia's Development and Reform Commission (DRC), proposed a regulation to shut down all cryptocurrency mining facilities in the region [17]. The Inner Mongolia DRC is a local branch of the country's National Development and Reform Commission, one of the Chinese government's 26 cabinets which is responsible for regulating economic activities on a local level. The proposal aims to fully "clear out and shut down all virtual currency mining projects by the end of April 2021" [18]. The proposal is currently receiving public feedback. Efforts to constrain annual growth in energy consumption to 1.9% was the stated motive for the regulation proposal. In a newsletter published on the 1st of March, BitOoda's Chief Strategy Officer Sam Doctor commented that part of the motive could be to close the ability of Bitcoin miners to circumvent capital controls. Doctor anticipates that we may observe such bans extending to other Chinese regions.

Other jurisdictional decisions in China have followed, with Bitcoin mining being banned or curtailed in both Xinjiang and Qinghai provinces in early June 2021 [155,156].Miners were also instructed to follow new regulations in Yunnan province the same month, including registering with local authorities [157].

Previous research has highlighted how the properties underpinning the Bitcoin network juxtapose the structure and practice of the Chinese government, making efforts to curb mining activities more likely in the region [19]. The Chinese government has implemented widespread censorship of information, through what is popularly known as the "Great Firewall of China" [20]. This censorship contrasts the censorship-resistant and politically agnostic nature of the Bitcoin network. Moreover, Bitcoin's permissionless payments provide a route for Chinese citizens to circumvent the capital controls imposed by the government.

In contrast, the US is a jurisdiction that can provide a high degree of clarity around business activities where sudden aggressive changes in regulation are much more unlikely. The imperative of some US mining companies to comply with existing regulations is a positive for how mining-related regulations might evolve moving forward. Some mining pools confirmed that they have carried out KYC on their connected miners while also investigating their payout addresses to ensure that the

addresses are unconnected with any addresses associated with illicit activities. DMG and Marathon Group contentiously took this a step further by launching a pool that actively censors transactions that are not compliant with rules set forth by the US Government's Office of Foreign Assets Control (OFAC) [21]. Marathon ultimately ended its censorship program in June 2021 after updating its nodes in compliance with the Taproot Bitcoin upgrade [159]. Overall, the imperative of established companies to act in accordance with US regulation is likely to positively frame any future discussions surrounding mining-related regulations.

It is also worth noting that several entities already, or intend to, provide mining pool services with the US as their operational headquarters. Luxor Mining, DMG, Foundry, and Titan will all provide mining pool services that primarily target US-based miners. Since the start of 2016, almost all of the Bitcoin hashrate has been connected to mining pool entities that have their operational headquarters in China [22]. Braiins is a notable overseas exception.

The majority of mining pools being based in China was a natural product of the majority of hashrate production residing within Chinese borders. Face-to-face discussions and relationship development are important factors when competing to capture such hashrate, which will be further discussed in the "History of Hardware" section.

Double-Edged Sword of the US Capital Markets

Publicly traded US mining companies are in an extremely advantageous position when it comes to competing for the limited supply of hardware, compared to smaller-scale miners or startups. Moreover, their track record of purchases, economies of scale, and access to financing enable these entities to access more attractive pricing. For example, a $170 million purchase of 70,000 Antminer S19 machines by Marathon announced on December 28th equated to a purchase price of roughly $25.56 per TH [10]. At the same time, retail miners were paying roughly $40.19 on the secondary market for latest-generation equipment, a 57% premium [5].

Access to cheap capital is one of the key factors underpinning this preferential access to mining machines. US publicly-traded companies have several methods for financing, with the US capital markets being the biggest in the world. Additionally, lower capital costs spurred on by US Federal Reserve interest rate strategies and monetary stimulus decrease capital costs for US based firms.

For example, consider the December 2020 debt offering by MicroStrategy. After cumulatively investing $475 million from their cash reserves into Bitcoin in the months leading up to December, MicroStrategy offered investors $550 million of unsecured convertible senior debt notes, with the option to purchase an additional $100 million. The yield on the bonds was 0.75% APY, 50-75 basis points above the Fed Funds rate. The offer opened on the 9th of December for 13 days and was filled on the 11th of December. Net of fees, MicroStrategy raised $634.9 million [31]. At the end of the five years, the total cost of their capital will be $24.4 million, paid off in increments over the course of the duration.

Cheaply raising capital has also extended to the Bitcoin mining industry. In January, Marathon raised $250 million by selling equity to several institutional investors, with the deal being brokered by H.C. Wainwright & Co [32]. The fees incurred to raise such an amount would likely have been a small fraction of the total capital raised.

Cheap Financing Increases Valuations

Access to cheap financing is only one of the benefits of being publicly listed. These companies are also trading at valuation multiples that would be outside the realm of reasonable possibilities for a private company.

In January 2021, several mining companies, including Marathon and Riot Blockchain, surpassed market valuations of over $1 billion [33, 34]. At the time, Marathon and Riot Blockchain operated 248 petahash (PH) and 842 PH respectively, placing their valuations per PH at over $4.03 million and $1.18 million per PH deployed [9, 35]. 1 PH is roughly 10 Antminer S19 mining machines that would currently generate roughly $10,000 per month when no costs are taken into consideration. If mining conditions remained the same, it would take over 100 years for the mining machines to generate the valuation that is assigned to their share of the company's hashrate. By April, Marathon and Riot Blockchain increased their installed hashrate to 1,400 and 1,600 PH respectively [36]. The market capitalization of both also increased, bringing their valuation per hashrate to $3.99 million and $2.99 million respectively [36]. Even when future expected hashrate for 2021 is taken into account, valuations remain at $538k per PH for Marathon and $1.26 million per PH for Riot.

While the market prices in future events, such as future mining machine deliveries and the resulting anticipated revenue, such valuations per PH would be unreachable by private companies. These high valuations can be strategically used by the management of publicly listed companies to expand their infrastructure.

For instance, in February 2021, publicly listed Argo Blockchain entered into a non-binding Letter of Intent (LOI) to issue shares to a New York company to purchase 320 acres of land in Texas with access to 800 MW of energy [37]. On the 8th of March, Argo Blockchain finalized the purchase with the intention to build a 200 MW facility over the next 12 months [38]. Riot Blockchain has also expanded their infrastructure with the acquisition of Texas-based Northern Data, which was partly executed by issuing shares to Northern Data [39].

Such valuations and the increased negotiating power that comes with them is certainly a strong incentive for private miners to IPO. Industry professionals anticipate that several mining companies will pursue US IPOs over the following year. The public market can also impose additional pressure on mining companies. During market conditions where Bitcoin price approaches the breakeven levels for some miners, the expenses associated with operating a publicly-traded company add additional pressure.

Public Versus Private

Private companies do not incur the costly financial reporting requirements of their public counterparts. This places them in a healthier position should market conditions significantly reduce their revenue. The freedom from stringent financial reporting also allows private companies to experiment with innovative technologies without broadcasting such developments to the wider industry. When Riot Blockchain began exploring an 8 MW pilot project in Texas with technology infrastructure companies Lancium and Enigma, this initiative was announced publicly [40]. Should the pilot project radically reduce input costs, the development may spur others to explore such opportunities and diminish Riot's advantage. However, a private mining company has no obligation to report such initiatives. Some private mining companies may have a distinct advantage in how they establish their cost structure.

On the other side, private mining companies will not experience the lofty valuations of public mining companies and will also face a significantly higher cost of raising capital. Outside of the public markets, the cost of raising capital will vary more widely. The company's risk profile and the industry in which it operates will significantly impact this cost. For debt financing, the interest rate will rise when a high demand for financing meets a limited supply. In the case of the mining industry, there are few commercial lenders and an everlasting need for capital due to the imperative of most miners to continuously increase their hashing output. This raises the costs of raising capital significantly higher than those faced by publicly traded companies.

Burgeoning Financial Services

The growing demand for capital from US miners is evident from several institutions emerging to address financing and other services in the mining industry. Galaxy Digital announced the launch of a miner financial services business line that will offer lending, investment, and risk management services [41]. In September 2020, Digital Currency Group launched Foundry – a mining-focused subsidiary that will provide services to United States miners, including hardware procurement and financing services. Digital Currency Group committed $100 million towards Foundry building out its services [42]. Foundry also secured a partnership with MicroBT to gain priority access to new Whatsminer machines for their North American customers [43]. With this partnership in play, Foundry simultaneously caters to both hardware procurement and financing for fleet expansions and upgrades.

Access to financing is only one facet of how the broader capital markets can serve miners and that is evident from the broader suite of services being offered by companies like Galaxy Digital and Foundry. Miners can choose from a myriad of companies to access lending and derivatives markets. BitOoda offers several fully-regulated derivatives products targeted at miners that allow large-scale mining companies to hedge their risk exposure. The usage of Bitcoin-collateralized loans has also been growing. Data from Credmark estimated that there was over $25 billion in Bitcoin-backed loans outstanding at the end of 2020 [44]. Such credit markets can serve a useful function for Bitcoin miners, enabling them to meet operational expenses without liquidating their current BTC holdings. Several US enterprises offer such lending services to institutions, including BlockFi, Genesis, and Unchained Capital. BlockFi and Genesis were estimated to have $4.4 billion and $3.8 billion in outstanding Bitcoin-backed loans at the end of 2020 [44].

US versus Overseas

However, the US is infamous for its intensive oversight on securities, which leave miners with fewer options in the short-term compared to overseas. Overseas entities like Poolin and Binance have launched token instruments that are tied to the value of hashrate [45]. US companies will refrain from launching products that likely classify as securities, due to the stringent oversight of the SEC and CFTC. This may give US miners fewer options in the short term. In the long-term, US companies can be expected to work within the boundaries established by regulators to launch innovative financial products.

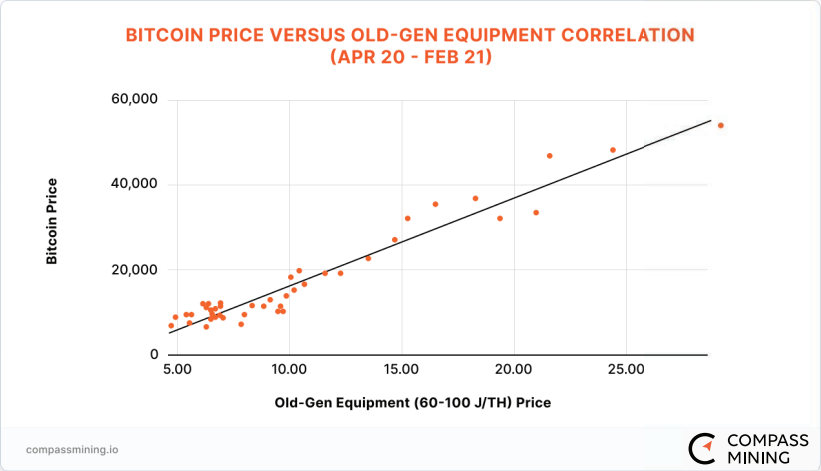
The concept of liquid markets surrounding hashrate and difficulty has been given much attention in the industry. We have observed such markets in a rudimentary form with the launch of hashrate and difficulty-based derivatives. Some US entities have listed working on the development of widely adopted liquid hashrate and derivatives markets among their imperatives. The financial products and services at the disposal of US miners can naturally be expected to grow more versatile and liquid as the industry grows and more entities emerge to service miners. Currently, the biggest advantage of the US capital markets is the ability for publicly traded mining companies to access cheap and abundant capital, capitalize on lofty valuations, and intensely compete for a constricted hardware supply.

Hardware supply is the key constraint facing Bitcoin miners globally. With a nearly insatiable demand from efficient miners to increase hashrate, the supply of new mining machines is insufficient to meet market demand. Demand-supply imbalances exacerbate during spans of lucrative mining conditions. In the competition to secure supply, mining facilities commit to purchases with lengthy future delivery dates as was highlighted by the December 2020 purchase of 70,000 Antminer S19 by Marathon with delivery times spread throughout 2021 [10]. Mining machine supply constraints in late 2020 and early 2021 are further exacerbated by global semiconductor shortages. Sectors like the US auto industry have had cases of halting production and furloughing workers due to an ability to secure semiconductors in a market where demand far outweighs supply [46].

Hardware Market Characteristics

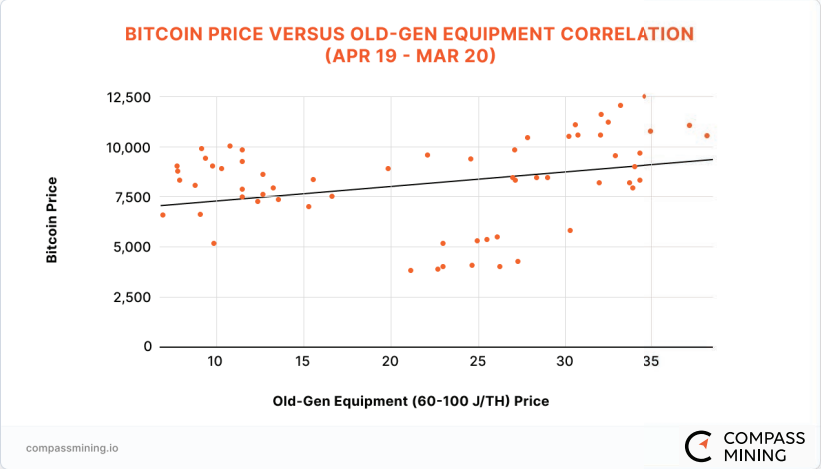
Miners that can't secure hardware from manufacturers are forced to pay premiums in the secondary market or purchase through brokers that add a significant markup to equipment. Brokers typically add markups of 6-15% for new equipment and 15-25% for used equipment. The secondary market also incorporates a significant premium compared to purchasing directly from manufacturers, as highlighted by the 57% difference between what Marathon paid for Antminer S19 machines and the price of sale on the secondary market [5, 10].

Given that Bitcoin price directly impacts the profitability of mining, the price movement of latest-generation mining machines is positively correlated with Bitcoin price. From April 6th 2020 until the 22nd of February 2021, weekly data for latest-generation mining machines with an efficiency of under 38 J/TH recorded a correlation coefficient of 0.968 with Bitcoin price, almost perfect correlation [47].

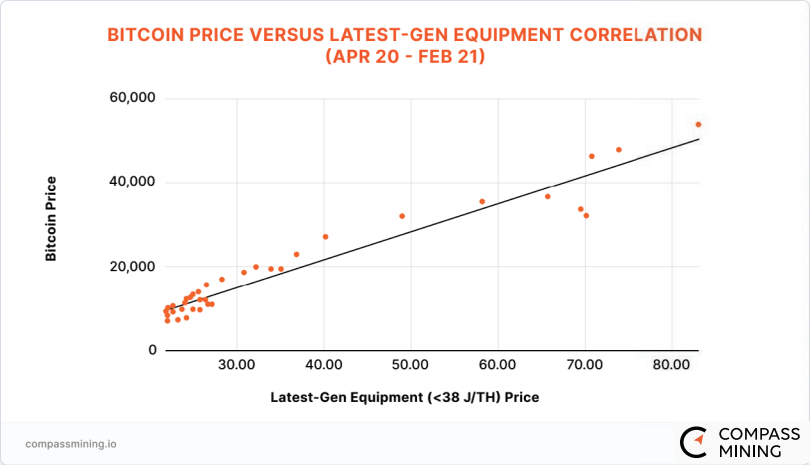


Before the Antminer S19 and Whatsminer M30S mining machines became the latest generation, Antminer S17 machines were the most efficient on the market. Released in April 2019, the initial S17 model touted an energy efficiency of 45 J/TH. S17 machines were positioned as the latest-generation until the release of the S19 series in April 2020. While these machines were the latest-generation, the correlation coefficient between weekly Bitcoin price data and mining machines in the bracket of 38-60 J/TH between April 1st 2019 to March 30th 2020 was 0.403, moderately positively correlated but far less so than the previous dataset [47].

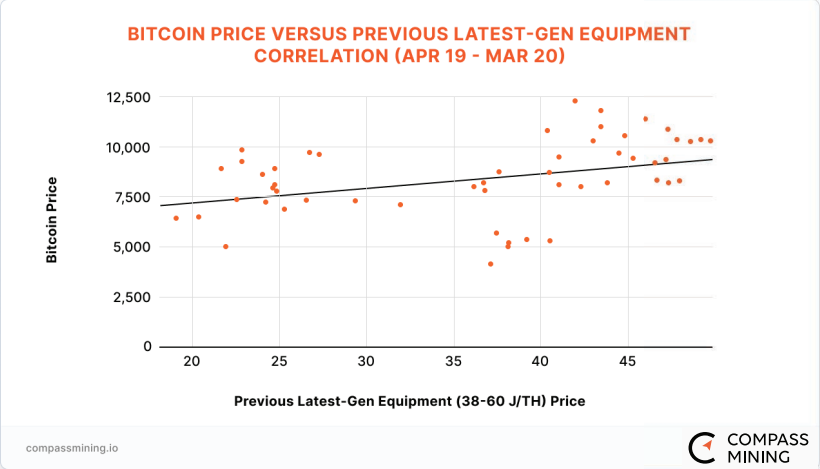
The lower correlation strength could be attributable to several factors like more bidirectional Bitcoin price movements in the time analyzed, the inclusion of some mid-gen machines in the 38-60 J/TH efficiency bracket, and a high failure rate in the S17 series of hardware. Data suggests that more bidirectional Bitcoin price movements, or more weeks where Bitcoin price recorded declines, may be a contributing factor to the lower correlation strength. In the first dataset (April 2020 to February 2021), 32 of the 47 weeks analyzed, 68%, recorded Bitcoin price increases whereas, in the second data set (April 2019 to March 2020), only 25 of the 52 weeks analyzed, 48%, recorded price increases [47]. It makes intuitive sense that Bitcoin price conditions are a significant contributing factor to the correlation strength between price and machine price. As the price of bitcoin rises, demand for mining will naturally increase. However, given the lack of supply in the hardware market, a lower Bitcoin price might not necessarily reduce demand.



This reasoning is further corroborated by the correlation of Bitcoin price data with old-generation equipment. The price correlation of Bitcoin price with mining machine equipment in the bracket of 60-100 J/TH, S9 series hardware, was 0.972 from April 6th 2020 to February 22nd 2021.



In contrast, the correlation dropped to 0.273 when the data was analyzed between April 1st 2019 and March 30th 2019. Correlation may also decline as equipment advances in generation, as the market size interested in such equipment becomes progressively smaller, as only those with the most competitive power prices will be able to profitably operate such equipment. However, the stark contrast in correlation figures suggests that Bitcoin price conditions are the prevailing factor impacting the correlation.



Fluctuation in hardware prices presents a challenge to institutional buyers. In times of volatile Bitcoin market conditions, hardware prices will vary day-to-day. This adds an extra layer of complexity for institutions that may have strict risk and compliance measures. Given that brokers add a significant markup, they are more suitable for smaller-scale and retail miners, as opposed to industrial miners who aggressively minimize input costs. Institutional miners will typically secure hardware from vendors. Manufacturers typically keep their prices stable for at least two weeks which makes the procurement process smoother compared to the secondary market where prices fluctuate daily. Moreover, institutional and large-scale miners can leverage long-term relationships with vendors to secure preferential pricing compared to what a smaller-scale miner could expect to negotiate.

Historical Hardware Procurement Difficulties Facing US Miners

Until recently, the hardware procurement process faced by United States miners was marred with friction and complications. Miners were forced to fully prepay for mining machines several months in advance. As manufacturers were based in China, this meant wiring payment to an overseas entity. United States miners also had little control over the delivery process. Equipment may be delivered to a state that was distant from a miner's facility and further delivery would need to be organized by the miner. There are several reports of orders only being partially fulfilled and pre-used mining machines being delivered. Manufacturers mining with hardware before delivering it to customers is an unconfirmed but widely believed facet of the early-stage Bitcoin ASIC manufacturing industry. With two of the five major hardware manufacturers after publicly listing, and the market leader Bitmain working towards an IPO, such purported practices are quickly becoming anachronistic as professionalism improves among the major manufacturers.

Miners in the US have historically been at a distinct disadvantage to Chinese miners. Chinese miners could develop close relationships with their domestic manufacturers and position themselves as a priority to receive new mining machines releases. The initial deployment of new generations of mining machines, especially in the early generations, were particularly profitable, as the mining machines were deployed at a difficulty level that has yet to register more powerful mining machines coming online.

US-based miners have also faced historicallyunfavorable dynamics on the hardware front. Significant geographical distance from the hardware manufacturers means that United States miners can expect to receive equipment several months after their Chinese counterparts, with difficulty levels after adjusting to reflect more powerful hardware coming online. United States miners were also at a disadvantage due to the dissimilar business practices in China. Personal relationships and networks play an important role in how business is conducted in China. Guanxi ( ) is a Chinese term that expresses the importance of developing such personal networks. Their presence and personal connections with domestic manufacturers have historically secured preferential treatment for Chinese miners. Overseas miners were also at a disadvantage when it came to industry developments and hardware repair. The Bitcoin ASIC manufacturing industry wholly resided in China and there was a significant separation between Chinese miners and miners operating elsewhere. Relations between China and the United States have also been turbulent on a political level. During the Trump administration, the government imposed a 2.6% duty and 25% tariff on hardware imported from China [48].

Hardware Manufacturer Institutionalization

This has slowly changed and the disadvantage faced by United States miners has been dissipating. When mass-scale ASIC manufacturers initially emerged in 2013, the market they addressed was vastly different from the one they face today. The annualized coinbase rewards earned by miners grew from under $20 million at the start of 2013 to a market worth of over $10 billion in 2021 [49]. The increasing value inherent in the industry is accompanied by an increasing institutionalization of ASIC manufacturers. Two ASIC manufacturers – Canaan and Ebang – have carried out IPOs in the United States. The market leaders Bitmain and MicroBT are both anticipated to follow with their respective IPOs. The reality of being a publicly traded company servicing a multi-billion dollar annual market starkly contrasts the conditions facing a 2013 Chinese startup that is venturing into a high-risk market with immensely uncertain prospects. Being publicly-traded demands much higher levels of professionalism from listed enterprises. Instances of uncertain hardware deliveries and used equipment being delivered will be replaced by ironclad purchase agreements and ancillary services to maximize quality.

It is already evident that the environment facing overseas miners is vastly different from the one of previous times. Manufacturers are frequently carrying out large purchase orders, reducing the risk faced by an institution that embarks on securing such an order. This is far more suitable for large institutions that may have strict risk and compliance measures. In previous years, the uncertainty relating to whether a manufacturer could successfully deliver an order was far greater. Manufacturers have also placed a greater emphasis on servicing overseas clients. Both Bitmain and MicroBT have established facilities in Southeast Asia to allow United States miners to circumvent the 25% tariff on equipment imported directly from China [43]. Partnerships are being formed with overseas mining companies. For instance, Core Scientific operates an in-warranty repair center for Bitmain's Antminer mining machines. Foundry has secured a partnership with MicroBT to gain priority access to equipment for the United States institutional miners that they work with [43].

As it stands, hardware is the defining bottleneck for growth in the US mining industry. Increasing professionalization is one factor that has unfolded in favor of the US mining industry. However, there are several more unfolding that could radically change the scale of Bitcoin mining in the US. In Chapter 2, we consider how the hardware industry may evolve moving forward and its connotations for US miners.

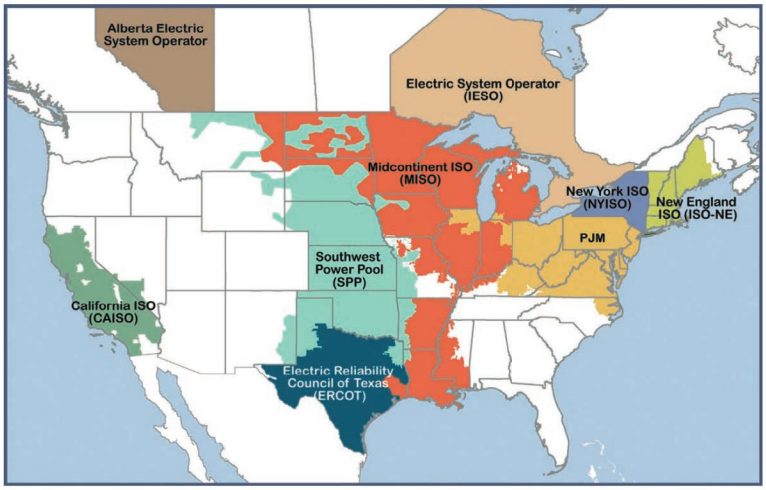
The Complexity and Opportunity in the US Energy Market

The United States is an extremely energy-rich country with a production of roughly 101 quadrillion BTU, ranking the country as the largest producer of energy after China [50]. Harry Sudock has noted that "power availability" is one of the main factors making the US an attractive region for miners [4]. The electricity market in the US is extremely complex, with its structure and regulations varying from state-to-state, and most operators servicing multiple states. Sourcing electricity can also be a challenge in some cases, but circumstances will widely vary depending on the region.

Sourcing Energy in the US Electricity Market

Consumers in the US market can either source their energy behind-the-meter, directly from a power provider, or in front of the meter, through a deregulated competitive wholesale market or a regulated utility company. On a state level, the reality facing miners sourcing energy will vary widely based on the specifics of each state. Roughly one-third of the country's electricity demand is met via traditional regulated electricity markets where vertically integrated utility companies serve consumers [51]. These markets exist primarily in the Southeast, Southwest, and the Northwest of the US. Utilities hold exclusive territory rights in these areas. Large-scale consumers can negotiate directly with the utility companies to secure a power price. It is also possible to secure behind-the-meter energy in these markets. These regions are mapped in white on the below map.

North American Independent System Operators and Regional Transmission Organizations



Source: Velocity Suite, ABB

(Source: ferc.gov , 51)

Roughly 2/3rds of electricity demand is located in a deregulated jurisdiction which is primarily serviced by one of the nine Independent System Operators (ISO). These regions operate through competitive market mechanisms with supply-side power sources bidding to be included in the market. The role of the ISO is to ensure that demand matches supply and to source the lowest cost energy for the grid. The ISO's are labelled on the above map. The Electric Reliability Council of Texas (ERCOT) is a particularly pertinent ISO for miners.

Texas offers extremely attractive conditions for both miners who source behind-the-meter and those that participate in the ERCOT market. Bitcoin miners in the ERCOT market can significantly reduce their effective power price by participating in demand-response programs. ERCOT is particularly prone to volatile power prices which fosters extremely lucrative conditions for participants of demand-response programs. West Texas is a particularly attractive region due to finite transmission infrastructure. West Texas is a hub for wind power production but has limited local demand. Electricity prices can turn negative in the region to incentivize wind producers to disconnect from the grid. Wind producers will often persist to produce until rates turn to a given negative level as they receive subsidies from the federal and state governments for their renewable energy production.

ERCOT Cost Breakdown and Demand-Response Programs

Base energy prices in the ERCOT market are extremely competitive. Over the past five years, the wholesale base energy cost averaged roughly $0.03 per kWh [52]. Uplift charges are limited and are roughly $0.002 per kWh. ERCOT is the only US ISO with no capacity payments and renewable energy credits are nearly non-existent, bringing the costs associated with these close to zero. The distribution of energy can be split into two parts – transmission and distribution. The transmission consists of high-voltage transmission lines that transfer energy from generators to consumption hub load zones like cities. The cost associated with the transmission is roughly $0.006 per kWh. After the high-voltage transmission lines, the energy is carried through a transformer where it is transferred to lower-voltage distribution lines that deliver it to the end consumer.

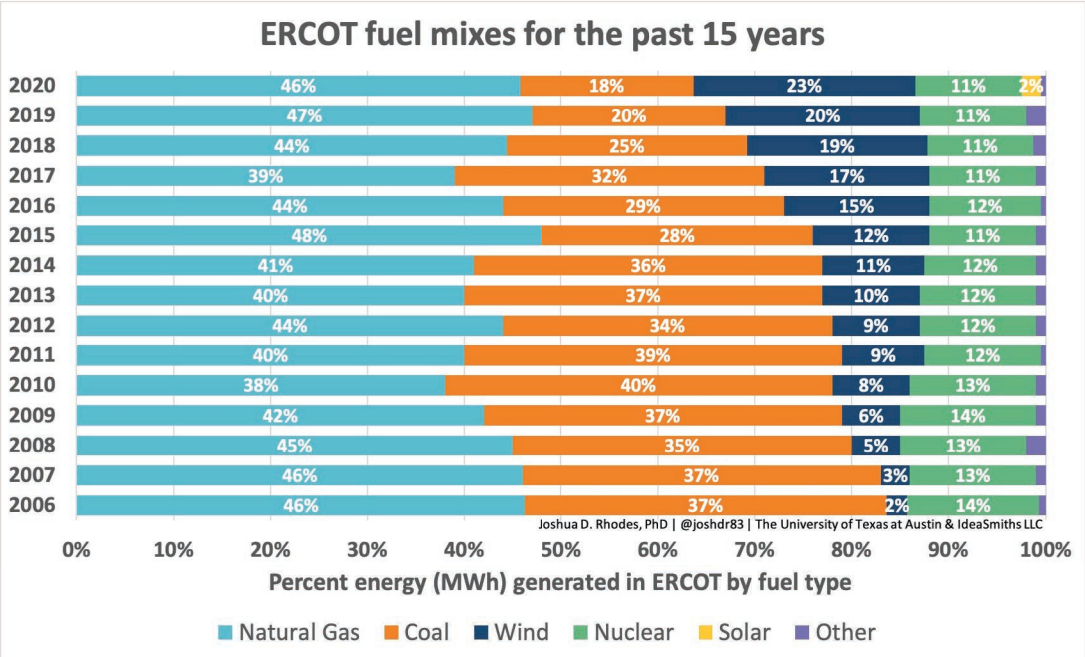
Distribution charges can be avoided by building a private substation that connects to the transmission lines. Transmission line charges can also be avoided by curtailing energy during what are called "coincident peaks" of demand during the summer months of June through September. These can be easily forecasted by consumers. However, the ERCOT market is particularly attractive to miners as they can significantly reduce their effective power price by participating in the market's other demand-response programs.

In ERCOT, there are two types of demand-response program participants, known as Load Resources (LR). A Controllable Load Resource (CLR) is capable of controllably reducing or increasing consumption in response to signals by ERCOT. A non-Controllable Resource (non-CLR) gives the right to ERCOT to curtail their energy consumption under certain circumstances. In the ERCOT market, LRs can participate in the Regulating Reserve Service (RRS) AS product market where Load Resources agree to give the system operator, ERCOT, the right to curtail the LR's energy consumption to address large unforeseen frequency drops in the grid that require additional energy or load interruption to restore the frequency back to normal levels. LRs are compensated for participating in this program. The RRS price is typically highest when the opportunity cost for generation is at its highest. CLRs can also participate in additional demand-response programs such as Reg-Up/Reg-Down and Non-Spin.

The RRS AS program is oversubscribed and LRs only receive prorated compensation on their bids. In 2020, approximately 7,000 MWs competed for 1500 MWs of RRS [52]. The rewards were distributed proportionally and LR participants received roughly 37 cents on every dollar for their RRS offers [52]. A more attractive option for consumers is participating in the demand response programs that are available to CLRs. However, the requirements for becoming a CLR are higher and require entities to demonstrate technical characteristics similar to a power generator like receiving baseline directives from ERCOT and being able to ramp up and ramp down energy consumption. CLRs must be able to instantaneously respond to frequency deviations on the ERCOT grid. Those that participate in the CLR program do not compete against those in the LR market. They compete against power generators who face real opportunity costs when offering to sell energy versus participating in demand-response programs. As long as the CLR has an offer price that is less than what was offered across the power generation, they will receive a full award and receive the full reward amount. By participating in the CLR demand-response programs, the potential to reduce your effective electricity price is far greater compared to other US ISO's. CLR participants are also agnostic to location as participation is grid-wide and the rewards for participating in the CLR program are priced according to the most volatile power prices across the ERCOT grid. Lancium is a technolo-

gy infrastructure company in Texas that has a patented software – "Smart Response" – designed to enable Bitcoin miners to be eligible for participation in CLR demand-response programs. In August 2020, Lancium entered into a lawsuit with Texas company Layer1 for patent infringement [53]. The litigation was settled in March 2021 with Layer1 resolving to licence the "Smart Response" software [54].

For the past two years, providing such demand-response services through CLR demand-response programs has enabled consumers to reduce their base power price by roughly 50%. For comparison, the demand response programs in the New York ISO (NYISO) enables consumers to reduce their base power price by roughly 15-20%. The energy mix of the state plays a key role in determining the lucrativeness of demand-response programs. Roughly half of Texas energy production is generated by burning natural gas, and power plants keep little reserves on-site making demand-response programs more important during unexpected shifts in demand [55]. In contrast, the NYISO generates electricity from a more distributed energy mix. Notably, New York is the third-largest producer of hydropower in the US, which is particularly well-suited to catering to unexpected demand increases [56]. Moreover, an analysis by Joshua D. Rhodes shows that ERCOT has been sourcing an increased share of its energy from renewable sources. Coal is accounting for a lower portion of fuel mixes, making the role of demand-response programs like the CLR more important as the redundancy that was once in place from coal plants is being diminished. It took approximately 15 years for the percent of total annual energy generated by wind in ERCOT to progress from roughly 2% in 2006 to 23% in 2020. With solar representing 2% of generation in 2020, it is not improbable to think solar will follow a similar path to wind over the next 15 years. If this materializes, wind and solar would represent roughly half of the energy generated in ERCOT with coal continuing to lose its production share. In this scenario, having CLR entities available to ERCOT for primary frequency response and demand response programs overall will become more important for grid stability.



(Source: Twitter.com, 57)

Overall, Bitcoin miners in the ERCOT market can reduce their energy price by roughly 50% by participating in demand-response programs as a CLR. With power prices averaging roughly $0.03 per kWh in recent years, this means that miners could achieve roughly $0.015 per kWh [52]. With base power prices lower in some ERCOT locations, effective power prices lower than this can also be achieved. Miners need to be sophisticated when structuring their setup to eliminate transmissions and distribution charges. Distribution charges can be avoided by building a private substation to connect to transmission lines and transmission charges can be avoided by curtailing during the above mentioned "coincident peaks".

Participants in programs available to CLRs experienced a particularly lucrative period during the demand-supply imbalance which surfaced due to the low February temperatures in Texas. Power prices reached their cap of $9 per kWh for consumers. Prices for selling ancillary services exceeded this and reached roughly $22 per kWh. In a newsletter published on the 24th of February, BitOoda Chief Strategy Officer Sam Doctor estimated that miners who could sell their electricity back to the grid would lower their effective annual power price by $0.0006 to $0.001 per kWh for every hour they could sell their energy back to the grid.

Unsurprisingly, several companies have chosen Texas as their location of operation. Riot Blockchain, SBI, and Bitmain are among the well-known companies with miners in the state [39]. As discussed in the capital markets section, Argo Blockchain is also entering the Texas region with a 200 MW facility expected to be built by March 2022 [38]. Given that the mining industry thrives on aggressively reducing input costs, it is reasonable to anticipate a power law emerging where the majority of US hashrate production takes place in the Texas region.

Bitcoin Mining in New York

After Texas, Upstate New York has been another attractive region for Bitcoin miners. However, it presents some unique challenges to entry and a higher political risk after entry. In a few NYISO municipality regions, base power prices of roughly $0.03 per kWh can be secured. By participating in the demand-response programs in the NYISO, it is possible for miners to reduce their base power price by roughly 15-20%. The ability to reduce your base power price through programs in the NYISO is not as attractive as ERCOT due to several factors. Electricity prices in the NYISO are less susceptible to the large spikes that occur in Texas. One factor playing into this is ERCOT being predominantly powered by natural gas whereas hydropower accounts for a significant portion of the energy production in New York, which can oftentimes be utilized to meet demand spikes. Hydropower can also be imported from Quebec, giving the NYISO a greater degree of redundancy in terms of energy reserves and less dependency on demand-response programs. This results in demand-response programs being less lucrative for miners in the region. Outside of a few municipal regions, there are several additional costs charged to energy consumers in the NYISO. Uplift charges, transmission and distribution charges, and renewable portfolio charges are all examples of costs that raise the power price for NYISO consumers. Unless miners can secure energy in a municipality or receive an economic development subsidy, the lowest power price they will pay is roughly $0.05 per kWh.

Regulated municipalities that have inexpensive power prices in Upstate New York include Massena and Plattsburg. These municipalities are predominantly powered by low-cost hydropower. Access to the low-cost power in these regions is determined by the local municipality. Entry into these pockets can be particularly challenging for Bitcoin miners. For instance, in Plattsburg, there is a moratorium on additional Bitcoin mining coming into the municipality. In these regions, there is a large demand for low-cost energy with a limited amount of hydro that can be allocated. However, if miners can successfully enter these areas, they will access some of the lowest electricity prices nationwide. Coinmint is one Bitcoin mining facility that is based in Massena and has reported an annual average power price of roughly $0.015 per kWh [58]. In Plattsburg, there is also sub $0.02 per kWh of power.

Bitcoin miners in New York face a higher political risk, compared to Texas. Entities in the predominantly Democratic state of New York are more likely to raise concerns with the energy consumption dedicated to Bitcoin mining, compared to the predominantly Re-

publican state of Texas [59]. For instance, a lawsuit has been filed against an Upstate New York energy company that mines Bitcoin, Greenidge Generation, with the plaintiff, a mixture of 25 organizations and individuals, claiming that the operation could have negative environmental impacts [60]. There is also a greater risk of unfavorable changes on the state level. For instance, the New York State Senate has proposed a law that would impose a three-year moratorium on all cryptocurrency mining activity within the state for the purpose of carrying out a detailed study on the environmental impact of Bitcoin mining within the state [61]. The bill later failed in the state Assembly after a labor union denounced the ill effects of the bill against certain industries [158].

Bitcoin Energy Consumption Concerns

The energy consumption of Bitcoin mining is a recurring topic in the media. Critics continuously raise concerns regarding the energy draw of the network, which is comparable to the energy consumption of a country around the size of Argentina or Norway [62]. The latest instance of widespread media concern regarding the topic took place after Tesla announced its Bitcoin purchase, and later suspension of a program enabling the purchase of Teslas with Bitcoin due to energy usage concerns. This spurred several well-known publications to question whether the purchase of bitcoin, along with its associated energy consumption, was contradicting Tesla's mission of building an environmentally-friendly product [63].

In recent years, there has been more nuanced discussion surrounding Bitcoin's energy consumption but such media outbursts continue to persist. In this subsection, we explore the main angles that need to be considered in relation to the Bitcoin energy consumption concerns. At the foundation of the critiques against Bitcoin's energy consumption is the assumption that energy consumption is inherently bad. However, it is the carbon emissions tied to energy consumption which are harmful. Energy consumption alone is not harmful and has historically been tied to higher quality of life.

"The accomplishments of human civilization have largely been achieved through the increasingly efficient and extensive harnessing of various forms of energy to extend human capabilities and ingenuity. Energy is similarly indispensable for continued human development and economic growth. Providing adequate, affordable energy is essential to eradicating poverty, improving human welfare, and raising living standards world-wide."
— (Hans Holger-Rogner and Anca Popescu, 64)

It is not the overall energy consumption of Bitcoin that should be perceived as harmful but the emissions related to the energy consumption. The level of carbon emissions vary widely depending on the fuel source. Coal is particularly carbon-intensive with 900 grams of CO2 emitted per kWh generated by coal power [65]. Renewable energy sources also contribute to emissions externally through their construction process but to a much lesser extent [65]. Several attempts have been made to estimate the percentage of Bitcoin mining powered by renewables. Estimates in recent years have varied from 39% to 73% [66, 67]. However, while a significant portion of the Bitcoin hashrate production remains in China, the renewables percentage will largely depend on the time of year. During the Chinese rainy season, which takes place from roughly April to October, a large percentage of Bitcoin network hashrate is estimated to operate in the Soutwestern regions of Sichuan and Yunnan [7]. These regions have an abundance of hydropower during the rainy season, raising the share of hashrate production being fueled by hydropower. Outside of these months, a large portion of the hashrate transitions to the Northern provinces Xinjiang and Inner Mongolia. These provinces are dominantly powered by coal, lowering the renewables percentage and raising the emissions associated with Bitcoin mining activity. Chinese government subsidies to coal-power plants make this power source the cheapest alternative [68]. In 2015, the Chinese government provided roughly $15 billion worth of subsidies to coal power plants [68].

However, in North America, an entirely different scenario presents itself. The costs associated with devel-

oping renewables infrastructure is declining and states, municipalities, power producers, ISOs, and companies are showing an imperative to transition a greater share of their energy consumption and production to renewable sources. In the ERCOT market, coal is being phased out in favor of renewables like wind and solar [57]. Other ISOs have been following a similar trajectory and the policy stances of several major power producers also favor transitioning towards renewables. The Midcontinent Independent State Operator (MISO) has been working towards transitioning to more renewables, setting policies to phase out coal and natural gas in favor of solar and wind [69]. Over the past ten years, the Alberta Electric System Operator (AESO) has reduced their share of coal power generation from 44% to 31% with a greater share being attributed to wind and solar [70, 71]. US corporations are also showing intentions to source their power from renewable sources. A Deloitte survey of 308 enterprises across various industries found that roughly half sought to add more renewable energy power to their mix [72]. Moreover, North American policies have been incentivizing a transition to renewables. As will be highlighted in Chapter 3, a large portion of the energy mix fueling mining operations in Canada is attributable to hydroelectric power and the country is also heavily taxing fuel sources that are carbon-intensive. In the US, roughly a dozen states have a regulatory mandate to increase their renewables energy mixture share to 50% or more [72].

If the US can scale its Bitcoin mining industry to the same size as China, a question that will be further explored in Chapter 2, such a development will significantly reduce the amount of carbon emissions tied to Bitcoin mining. Such a development will likely alleviate the concerns raised by critics but it is unlikely to eradicate them. However, there are several further angles that also need to be considered in relation to Bitcoin energy consumption criticisms.

Firstly, critics often tie the energy consumption of Bitcoin to its transaction throughput, deeming it to be inefficient. While the transactions per second is roughly estimated to be 7, the effective transactions per second is much greater. Activities like batching, layer-2 payments, and off-chain payments facilitate a much greater transaction throughput which are all ultimately settled on the Bitcoin base layer [73]. Moreover, arguments relating to the transaction throughput fail to account for the fact that many are utilizing Bitcoin for purposes unrelated to its transaction capacity. The censorship resistant and supply properties of Bitcoin are other strong motives for users of the network.

Secondly, the location-agnostic nature of Bitcoin mining activity allows operators to establish activities near areas of stranded energy. This includes both renewables production that has insufficient transmissions capacity and natural gas that is being flared into the environment as a result of oil drilling.

Exploring Underutilized and Stranded Energy

A small share of hashrate has been experimenting with sourcing stranded energy sources. West Texas offers the possibility for miners to establish operations nearby congested energy production. Texas has 28.8 GW of wind power production capacity installed, mainly concentrated in West Texas [74]. Local demand in West Texas is only a fraction of the production capacity. The transmission infrastructure is finite and a significant portion of the energy production cannot be transferred to the main demand zones in the East and North. The remote nature of Bitcoin mining operations allows them to establish operations nearby such production and alleviate the congestion. By alleviating some of the congestion and allowing more of the energy produced to be sold locally, Bitcoin mining may play a role in advancing infrastructure development such as building more transmission capacity. However, establishing behind-the-meter deals with wind power producers in West Texas comes with its own set of tradeoffs. While attractive base price power deals may be secured, miners would sacrifice the ability to participate in demand-response programs with the ERCOT grid and would also sacrifice uptime as the power production will be weather dependent.

Companies like Upstream Data, Great American Mining, and Crusoe Energy have emerged to form partnerships with oil and gas producers with the imperative of strategically redirecting their stranded energy to mine Bitcoin. Oil drillers will oftentimes not have the infrastructure to utilize the natural gas that is generated as a byproduct of the drilling process. Infrastructure like on-site gas capture equipment, processing plants, and pipelines would allow producers to sell the gas. Howev-

er, low natural gas prices rarely make this economically viable. Flaring and venting are the popular alternatives. The United States ranks behind only Russia and Iraq in terms of how much gas is flared annually [75]. In 2019, the United States flared 17.29 billion cubic centimetres of gas, while Russia and Iraq flared 23.21 and 17.91 respectively. With flare mitigation regulations being introduced in several regions, some producers are being forced to halt production when their flare levels reach a certain point. States like North Dakota are particularly strict on such regulations and have drones flying over oil fields to monitor CO2 release [4 , 76]. Installing infrastructure which would utilize this energy for Bitcoin mining is another option that has been receiving attention. While there has been much hype in the media about this concept, there has been a lack of nuanced discussion about the reality of implementing such solutions. Using the natural gas byproduct to mine Bitcoin requires placing containers with mining machines onsite and implementing infrastructure which allows the natural gas to power the machines. Such infrastructure includes a power generator and pipeline to connect the generator to the natural gas. Oil and gas producers need to consider whether the anticipated returns justify the capital expenditure.

Many questions remain over the feasibility and scalability of implementing such solutions. Operating onsite Bitcoin mining containers at oil and gas fields is an unproven concept and there may be factors that impact the economic viability of such operations. Uptime, repair and maintenance, and security are all factors that may harm theoretical returns. Given the small-scale nature of such operations, they would face unfavorable hardware procurement conditions if venturing independently. However, as it stands, many are partnering with companies like GAM, Upstream Data, and Crusoe Energy to implement such solutions.

The Emergence of the Energy Sector

There has also been growing interest and participation from companies in the US energy sector that are forming partnerships with mining companies or establishing proprietary operations. Such participation remains largely in an experimentative phase. It is widely anticipated that a significant number of energy sector companies will eventually begin establishing independent Bitcoin mining endeavours. As familiarity and knowledge of the Bitcoin mining industry increases, there will be less friction to energy sector companies entering. However, as it stands, partnerships between energy companies and mining companies will be more likely given the knowledge and expertise required to establish competitive operations. Mining companies also have existing relationships established in the industry, which is particularly important during instances of constricted hardware supply.

The nature of Bitcoin mining competitiveness offers utility companies and power producers the opportunity to position themselves among the lowest-cost, highest-margin Bitcoin miners. Energy costs account for the majority of a miner's operational expenditure. A survey of 125 miners carried out by Cambridge Center for Alternative Finance (CCAF) estimated that electricity accounted for 79% of a miner's operating expenditure [66]. While this figure will widely vary, energy costs typically account for the majority of a miner's operating expenditure. The results of the CCAF survey corroborate this [66]. Energy sector companies are uniquely positioned to minimize this portion of the costs. The noncommittal nature of mining activity also means that energy sector companies wouldn't have to deviate resources from their primary business activities – the production and sale of energy.

Partnerships between Bitcoin mining companies and energy companies are already being established. In October 2020, Marathon Patent Group formed a joint venture with Beowulf Energy LLC [77]. Through the joint venture, Marathon secured an electricity rate of $0.028 per kWh, powered by coal energy at a specialized facility in Big Horn Country, Montana. Under the agreement, Beowulf secured an ownership stake in Marathon. Further partnerships between the energy sector and mining companies are expected. In December 2020, Bitooda hired for the position of Chief Power Strategist, with the noted aim of adding value for "Bitcoin mining clients and also for independent power providers" [78].

There has already been an incident of a power provider establishing Bitcoin mining operations independent of a partnership. Upstate New York natural gas power plant Greenidge Generation established an on-site facility that consists of roughly 7,000 mining machines

[79]. The implementation of the mining machines and the electricity infrastructure to power them was part of a $65 million renovation project where the company also tackled several other projects like converting from a coal plant to a natural gas plant. With the capital expenditure for the renovation deployed, the operating expenditure significantly decreases as the plant can power the mining machines at the cost of producing energy, as opposed to the markup energy prices that competitors pay. The plant owners noted that this places them in a "favourable market position".

Chapter 1 Summary

"Imagine a topographic map of the world, but with local electricity costs as the variable determining the peaks and troughs. Adding Bitcoin to the mix is like pouring a glass of water over the 3D map – it settles in the troughs, smoothing them out."
— (Nic Carter, 80)

China has historically held a dominant share of Bitcoin mining hashrate. Hardware is a key factor behind China's large share of hashrate and will continue to be so in the short term. However, attractive power prices in provinces like Sichuan, Yunnan, Xinjiang, and Inner Mongolia have also played an undeniable role in allowing China's share of hashrate production to scale to the extent that it did. However, with electricity representing the majority of a miner's operational expenditure, it is logical to anticipate that the industry will eventually find the lowest possible power prices globally in the most politically stable jurisdictions. The Texas electricity market is too attractive for Bitcoin miners to ignore. Its complexity means that most of the mining industry still only holds a rudimentary understanding of how the market functions. We expect the knowledge gap between those who have successfully established competitive cost structures in the region and the remainder of the mining industry to narrow as more and more hashrate finds a home in the Lone Star State. The political stability of the US combined with the unmatched size of the country's capital markets will further propel a domestic industry that is quickly growing and becoming increasingly institutionalized. The ability of US miners to raise capital quickly and cheaply currently plays an essential role in the competition for a limited hardware supply. Hardware remains the defining constraint on domestic growth in the US industry. Chapter 2 is dedicated to exploring whether the US mining industry can reach the same scale as the Chinese industry. We explore how the ASIC hardware market might evolve in the coming years to alleviate the supply constraint faced by miners globally and we also consider how other factors weigh into the relative tradeoffs between mining in the US versus China.

Chapter 2
Can United States Miners Compete at the Same Scale as Chinese Miners

Since the advent of mass-production Bitcoin ASIC machines in 2013, the dominant share of hashrate production has been generated in China. Industry professionals have estimated that China's share of hashrate production was roughly 80% from 2015 to 2016 [4]. However, this has slowly been dwindling with recent estimates from industry professionals putting the current share in the range of 40%-60% after an increased migration of Chinese hashrate overseas [4].

From the latter end of 2013 to 2017, China was also the dominant trading venue for the global Bitcoin marketplace with the Chinese Yuan (CNY) representing the majority of fiat-to-cryptocurrency transactions. From August 2015 to January 2017, Bitcoin-CNY trading accounted for over 90% of Bitcoin-to-fiat trading volume [81]. This dominance quickly fell to minuscule percentages when the Chinese government outlawed cryptocurrency exchanges in early 2017 [82].

USD has since replaced the Chinese Renminbi as the top trading pair for Bitcoin. Roughly 69% of Bitcoin-to-fiat trading volume is denominated in USD [83]. Four of the top five cryptocurrency spot trading venues are US entities [84]. While US venues carry out the majority of Bitcoin-to-spot trading volume, it remains to be seen whether the majority of hashrate production can take place within US borders.

To date, Chinese miners have been extremely effective at industrializing the procurement and repair of hardware, and sourcing low-cost energy. The confinement of ASIC manufacturing within China, and lower cost structures have further concentrated the industry within Chinese borders. However, several US companies have sprung up with the raison d'être of bringing hashrate to North America. One professional described the goal of bringing hashrate to North America as a matter of "national security" while another tied the compute power behind the Bitcoin network to the "military-industrial complex" [85, 86].

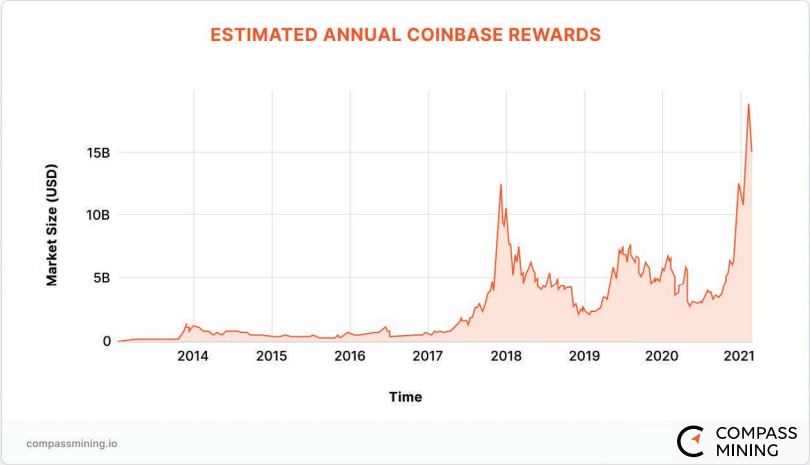
However, how feasible it is that the US Bitcoin mining industry can reach the same scale as China has only been explored at a rudimentary level. In Chapter 2, we consider how both the US and China industry have been evolving and what that suggests about their future shares of hashrate. As hardware remains the key constraint for scaling mining activity, the first part of the section is dedicated to addressing this area. This part analyzes how the Bitcoin ASIC manufacturing industry has evolved since its inception in 2013 and makes speculations regarding another major shift. The second part of this chapter analyzes factors beyond hardware and the tradeoffs they present to mining in the US versus China. Jurisdictional factors and the attractiveness of input costs are among the main considerations.

The Paradigm Shifts of Bitcoin ASIC Manufacturing

Historically, shorter delivery times and the ability to develop personal relationships with hardware manufacturers were distinct advantages for Bitcoin miners in China. However, the significance of this advantage has been diminishing. The evolving nature of the ASIC mining industry combined with longer hardware lifecycles has dissipated the advantage of operating in China. Moreover, recent developments suggest that the industry may undergo another major shift in the years to come. This shift holds the potential to entirely eradicate the hardware advantage Chinese miners hold over those operating in North America.

Greater Block Rewards Market Spurs First Major Shift

In Chapter 1, we detailed the uncertain and frictional hardware procurement process faced by overseas miners in the early stages of the Bitcoin ASIC manufacturing industry. The modus operandi of the industry began to shift in 2018 after the Bitcoin price appreciation of 2017 vastly increased the addressable market for manufacturers. At the start of 2017, the value of annualized coinbase rewards for the entire Bitcoin mining industry was less than $1 billion [49]. By year-end, the value had exceeded $10 billion [49]. Greater rewards spurred greater investment into mining equipment, increasing the revenue-generating possibility of the ASIC manufacturing business. This increase in revenue-generating potential catalyzed the first major shift in the Bitcoin ASIC industry.



What was previously a high-risk industry with widely opaque business practices began to evolve into an industry where manufacturers competed on professionalism and transparency. Bitmain – the leading ASIC manufacturer who reported representing 77% of Bitcoin ASIC sales in 2017 – began pursuing an IPO in 2018 [87]. Their IPO efforts would be closely followed by Canaan and Ebang listing in 2019 and 2020 respectively. While Bitmain has yet to IPO, a corporate restructuring in January 2021 has set the tone for an IPO in 2021 [88]. Their closest competitor – MicroBT – thrived in 2020, as Bitmain experienced a turbulent period, highlighting the increasing importance of professionalism and reliability in the industry [89]. MicroBT is also speculated to be pursuing an IPO.

Second Major Shift Approaching

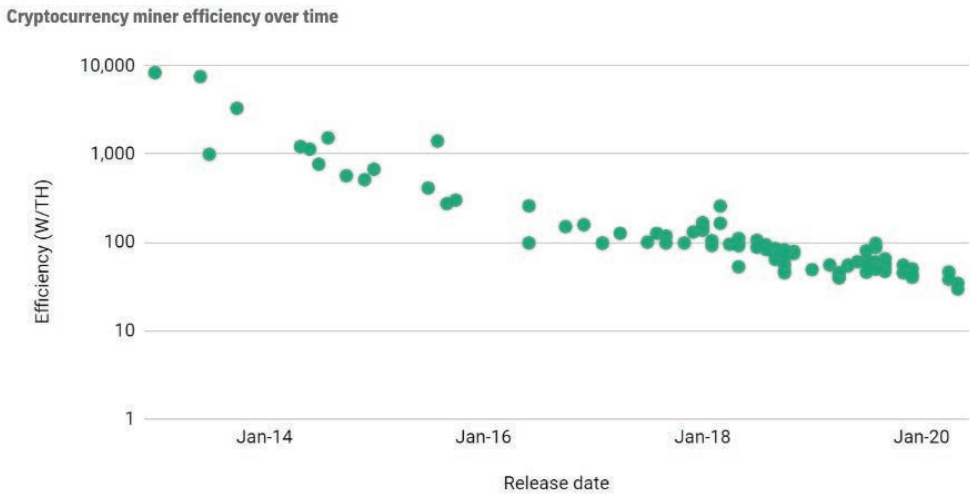
While the industry remains in its second major phase, recent developments suggest that the industry may experience another major shift in the coming years. The rise into a deca-billion annualized coinbase rewards market was brief in 2017 [49]. A sharp reduction quickly followed the rise in annualized coinbase rewards, putting a halt to plans that manufacturers may have held for expansion. Only two weeks were recorded in December 2017 and January 2018 where the annualized coinbase rewards market was over $10 billion. By comparison, as of the 1st of March, the coinbase rewards market has been over $10 billion for ten weeks and is showing no signs of returning to sub-$10 billion territory.

A vastly bigger block rewards market has important implications for how the hardware market may evolve. The Bitcoin mining industry, on aggregate, is theorised to operate slightly above the margin [90]. This implies that greater miner revenue generation will drive greater investment into mining infrastructure. This will result in greater revenue-generating capability for Bitcoin ASIC manufacturers. As with any industry, the increase in the market size will incentivize new entrants to establish operations and challenge the incumbents. While the incumbents – particularly Bitmain and MicroBT – have established a firm foothold on the market, the greater rewards available is anticipated to incentivize innovative engineering teams to emerge and seek to design competitive Bitcoin ASIC models. Moreover, the greater market size, combined with North America's increased share of Bitcoin hashrate, will increase the economic viability of incumbents establishing North American assembly lines.

However, the reality of North American manufacturers emerging is much more complex than the size of the block rewards market. A critical component of establishing a manufacturing business is solving supply chain issues. A hardware manufacturer may have to source electronics and hardware from thousands of suppliers, making the challenging logistics of launching such a business outside the realm of possibilities for most entities. Moreover, the global constraint on chip supplies means that a newcomer will struggle to secure a chip supply, and may have to prepay far in advance. With Samsung and TSMC setting up US foundries, industry professionals have estimated that we may observe these foundries allocate chip capacity for commercial applications like Bitcoin ASIC manufacturing roughly within the six to seven year time horizon [85, 91].

Hardware Lifecycles Lengthening Dissipate Chinese Advantage

While the emergence of North American manufacturers and foundries holds the potential to entirely disrupt the hardware advantage held by miners in the medium-to-long term, another factor has already been dissipating the advantage. In the early stages of the Bitcoin ASIC manufacturing industry, hardware life cycles were short and new generations of hardware would obsolete previous generations. However, this has become less relevant since the release of the Antminer S9 in 2016 as improvements in mining machine efficiency have significantly slowed down from generation to generation. The slowdown in efficiency improvements for new mining machine generations can be observed in the below chart which was presented in a research paper by Elwood Asset Management [92].



Several factors play into the slowing efficiency improvements. Chip size is the most important consideration. From 2013 to 2016, the size of chips used in Bitcoin ASICs rapidly reduced as new generations of machines were developed. Over this time, chip size shrank from roughly 110 nm to 14 nm. As a result, efficiency radically improved from roughly 10,000 J/TH to 100 J/TH. Older generations became obsolete as new generations were released. However, the shrinkage of chip size has slowed, resulting in the efficiency improvements being less pronounced. The Antminer S9, released in 2016 and using a 14 nm chip, had an efficiency of 98 J/TH. The Antminer S19, the latest-generation of machines, released in 2020 and using a 7nm chip, has an efficiency of roughly 38 J/TH.

This slowdown in ASIC efficiency improvement has important connotations for the relative advantages of mining in China versus the US. As noted in Chapter 1, being among the first miners to deploy new generations of machines has been particularly lucrative in the past. This has only been possible for the fraction of Chinese miners who can be among the first to secure new batches. However, as hardware life cycles lengthen, the advantages of such activities lessen. The impact of new generations on Bitcoin mining difficulty becomes less pronounced compared to the initial release of past generations. Longer delivery times also become a less relevant factor as mining machines can be expected to be profitable for several years. The ability to secure large purchase orders at attractive prices becomes more important.

Hardware remains the decisive constraint in the capability of the United States to scale its mining industry. Intense competition for the limited supply of new mining machines takes place globally among miners, with those in China having the benefit of being close to manufacturers and developing business relationships. From 2013-2016, this has been a particularly important factor which was evident from estimates of roughly 80% of the hashrate being produced within China at the latter end of this period [4]. However, an increased institutionalization of Bitcoin mining manufacturers, and longer hardware life cycles, has made this advantage less relevant. Nonetheless, it is still present. Another major shift in the structure of Bitcoin mining manufacturers may occur in the following years. A larger block rewards market, a greater share of hashrate production within the US, and the emergence of US foundries foster a more favorable environment for a US Bitcoin ASIC manufacturer or an incumbent manufacturer establishing a US assembly line. Should such a development occur, the advantage Chinese miners enjoy on the hardware front may dissipate to the point of irrelevance.

Factors Beyond Hardware

Apart from hardware, several factors impact the relative advantages of mining in the US versus China. The stability of the regulatory environment is among the most important of these factors. The existing literature suggests that Chinese Bitcoin miners operate in much more opaque territory when it comes to the legal certainty of their activities. There is a large difference in the treatment of Bitcoin miners among local jurisdictions. In some jurisdictions, local governments have advocated for Bitcoin mining activity while others have acted to hinder the activity by removing electricity subsidies and proposing mining bans. The fact that there are reports of cryptocurrency mining facilities framing their activities as cloud computing centers highlights the uncertain prospects facing Chinese miners [93]. For example, in 2020, an investigation of 30 facilities registered as cloud computing centers by a government agency in the Inner Mongolia region uncovered that 21 were cryptocurrency mining facilities [94]. The competitiveness of input costs is another key consideration that plays into the relative advantages of mining in China versus the US. Aggressively reducing costs is a primary imperative of miners. While power prices were considered in Chapter 1, this section explores costs related to infrastructure development and hardware migration.

Jurisdictional Certainty

The history of mining in China demonstrates that miners in the country face a much more uncertain regulatory environment. The consequences of jurisdictional opaqueness has impacted Chinese miners on several occasions over their history. In early 2017, a ban on exchanging between Bitcoin and the Chinese Yuan brought difficulties for Chinese miners looking to convert their bitcoin into fiat to meet their operational expenses [82]. Domestic exchanges with fiat on and off-ramps were outlawed as a result of the ban, forcing miners to source their conversion needs elsewhere.

In April 2019, cryptocurrency mining was included in the National Development and Reform Commission's (NDRC) list of industries to be phased out. The NDRC is one of 26 cabinets that form the Chinese government and are responsible for making economic policies that are passed on to local governments to enforce. The finalized list of industries to be phased out, which was published in November 2019, removed cryptocurrency mining [95].

In August 2020, a government agency in Inner Mongolia required that the electricity subsidies of 21 cryptocurrency mining facilities be stripped. This occurred after the agency uncovered that the data centers were cryptocurrency mining operations despite being registered as cloud computing centers. The uncertainty facing mining facilities in Inner Mongolia has exacerbated in 2021 as regulation has been proposed to ban cryptocurrency mining activities in the region [18]. Bitcoin miners registering their activities as cloud computing and attempting to secretly establish operations corroborates the uncertain legal environment faced by Chinese miners [96]. Moreover, the Wall Street Journal reported that industry insiders informed them that government authorities in China have accused some miners of money laundering and have frozen their credit cards [97]. Despite such regulatory uncertainty, competitive input costs act as a powerful incentive for miners to continue operating in the country.

Competitive Cost Structures

Chinese miners have the opportunity to procure competitive electricity prices in various regions. In Southwestern provinces like Sichuan and Yunnan, miners can secure as low as $0.012 per kWh during the rainy season due to the surplus of hydropower generated in the region. Power prices will be detailed further in the following section when seasonality and migration costs are discussed. Chinese miners also face preferential factors when it comes to sourcing energy and the build-out costs faced when developing infrastructure.

The World Bank ease of doing business data ranked China 12th out of 190 countries in terms of "getting electricity" [98]. The United States fared much worse, with a ranking of 64th. The increased difficulty of procuring electricity would likely play a minor role, given that miners will likely make their decision based on other factors like cost structures and jurisdictional certainties.

In terms of the costs of developing infrastructure, Chinese miners can secure costs that US miners can't compete with. It has been estimated by industry professionals that the buildout cost of mining facilities in China is roughly $25k to $50k per MW. The buildout costs faced by North American miners are significantly higher and can widely vary. Buildout costs for most operations are tentatively estimated to be in the range of $150k to $400k per MW. If the buildout is contracted to third parties, costs will be above $200k per MW.

Seasonality and Migration Costs

In Chapter 1, we detailed how we anticipate a power law distribution forming for hashrate production in the US, with the majority expected to find a home in Texas. Historically, such a power law distribution has been evident in China. One province has accounted for the majority of the country's hashrate production. Sichuan, a province with advanced hydropower infrastructure, has attracted the majority of the country's hashrate.

During the rainy season, which runs from roughly April to October, power prices in the range of $0.012 to $0.02 per kWh can be secured. Previous estimates during the

rainy season put Sichuan's share of hashrate at 37.4% of the Bitcoin network [7]. Outside of the rainy season, power prices rise to roughly $0.04 to $0.043. Outside of the rainy season, hashrate share estimates have varied from roughly 10% to 23% of the Bitcoin network [7].

At present, Sichuanese mining facilities are offering hosting contracts, which add a significant markup to base power prices, at a rate of $0.029 to $0.04 during the rainy season and a rate of $0.049 to $0.060 outside of the rainy season [99]. A significant share of miners choose to keep their mining machines in the region during the dry season. A significant portion typically aretransported to Northern provinces like Xinjiang and Inner Mongolia to maintain lower power prices. The cost of transporting such equipment is roughly $12 per machine but the biggest cost is incurred from the downtime. Transporting such machines can take 1-2 weeks. For a miner with 100 PH/s hashrate under management, an operation with roughly 1050 Antminer S19 machines, the cost incurred would be roughly $12,600 for transport but the missed mining opportunities would be ~$900k in current mining conditions [100].

The absence of a distinct dry season and wet season allows US miners to establish operations with year-round access to competitive power prices.Moreover, US mining operations are less likely to be destroyed at the hands of natural events. The rainy season in China can put mining facilities in the crosshairs of mudslides and flooding damage. With a significant share of Chinese hashrate production being based in the mountainous regions of Sichuan and Yunnan, these facilities are particularly at risk of being damaged or completely destroyed by a mudslide. In August 2019, the cofounder of 8BTC Red Li shared a video of such a mudslide [101]. The 2020 rainy season brought the worst flooding since 1998 and reports surfaced that several mining facilities were destroyed as a result [102].

Chapter 2 Summary

Hardware remains the defining constraint on the US scaling hashrate to the level of Chinese hashrate production. If the constraint on hardware were magically removed and US miners could source as much hardware as they desired, many US miners would source as much as their capital raising abilities allow them to. In this case, with access to the biggest capital markets in the world, the size of the US mining industry would almost certainly surpass China.

However, as it stands, manufacturing is confined to China and Chinese miners have historically had preferential treatment when it comes to securing supply. This is slowly changing as an institutionalization of manufacturers and miners makes professionally serving the growing US market more important. Moreover, a growing block rewards market, combined with the establishment of US foundries, increases the prospects that US manufacturers or Chinese manufacturers establishing US assembly lines will be observed.

Beyond hardware, year-round competitive prices and a stronger degree of jurisdictional certainty are some of the major relative advantages to mining in the US. As Bitcoin mining becomes increasingly institutionalized, we anticipate that these factors will become increasingly important and continue to grow the US share of hashrate.

Chinese miners are facing increasingly uncertain jurisdictional prospects. It seems likely that the US will surpass China's share in the coming years. However, we speculate that China will continue to hold a significant share of hashrate, even if the industry is banned nationwide. The buildout costs are simply too attractive for venturers to ignore. In the case that cryptocurrency mining is banned across China, we would expect to see the industry continuing as an underground activity with mining centers continuing to be framed as cloud computing centers and secret operations being established. The logistics of uncovering such operations would be extremely difficult for authorities, given the wide breadth of remote regions in China and the current phenomenon of some miners disguising data centers as cloud computing centers.

Chapter 3
The Canadian Bitcoin Mining Industry

While Bitcoin mining has been the subject of immense institutionalization and growth in the US in recent years, the seeds of a burgeoning Bitcoin mining industry in Canada have been evident for far longer. The advancement of Bitcoin mining in the US accelerated as the industry matured and gained a greater degree of approval by regulators. In Canada, cryptocurrency companies burgeoned at a much earlier stage, while the prospects of the industry remained riskier and more uncertain. Several cryptocurrency companies initially established their foothold before the asset class received mainstream attention due to the price appreciation of 2017. DMG Blockchain and Hut8 Mining are two examples of mining-focused companies that have been operating in Canada since before 2017. Moving into 2018, research suggested that Canada was one of the major mining hubs globally, alongside the US and China. Research by the CCAF estimated that the provinces of British Columbia, Alberta, and Quebec each had over 200 MW of energy capacity dedicated to cryptocurrency mining activities [103]. Manitoba was estimated to have roughly 100 MW of energy dedicated to crypto mining while Newfoundland and Labrador was estimated to have roughly 50 MW [103]. However, other reports suggest that on-grid mining only accounted for 6 MW of energy in British Columbia in 2018 [104].

In 2018, a country-wide energy consumption of 750 MW would have represented a significant portion of the Bitcoin network-wide hashrate. Cambridge Bitcoin Energy Consumption Index estimates from July 2018 put the network-wide annualized energy consumption at 50 TWh which equates to an energy draw of roughly 5.7 GW [105]. Such estimates would suggest that Canada represented roughly 13% of the Bitcoin network hashrate at that time, assuming that all of the energy was dedicated towards Bitcoin mining. Non-mining related cryptocurrency companies also surfaced, addressing a variety of areas in the broader cryptocurrency industry, leading Dan Tapscott to describe Canada as the "epicenter of the global blockchain movement" in 2017 [106]. Stock exchanges with less stringent listing requirements, like the Toronto Venture Stock Exchange (TSXV), have resulted in a diverse collection of cryptocurrency companies trading on the public markets in Canada. The risk profile of Canadian companies is generally higher compared to their US counterparts. This made the country more suitable for fostering early growth in the cryptocurrency industry.

However, the growth in the Bitcoin mining industry since 2017 has been somewhat hindered by a more bureaucratic regulatory environment. There have been incidents of moratoriums on power requests being put in place and also attempts to introduce industry-specific power prices. A myriad of regulatory bodies increases the risk that miners can be subject to changes that unfavorably impact their businesses. Provincial, federal, and municipal governments may also introduce changes that adversely affect mining operations. The introduction of the carbon tax is a development that will raise the costs for almost all energy consumers within the country. Moreover, there is a lack of clarity regarding how cryptocurrency assets should be treated. Each Canadian province having its own securities regulator further complicates matters. The regulatory guidelines that have been proposed suggest that compliance will be costly for some cryptocurrency businesses.

In this chapter, we will provide a high-level overview of the Canadian mining industry. We will dedicate a significant section of this chapter to understanding how the Canadian electricity markets work and how favorable the power prices that can be secured are. The regulatory environment is considered and we highlight how the high level of bureaucracy in the country has hindered the growth and scalability of Bitcoin mining. We will also consider the role that the Canadian capital markets played in the growth of the Canadian cryptocurrency industry and why more companies are likely to seek dual listings in both Canada and the US. Finally, we will review other favorable factors for mining in Canada, including lower hardware import taxes, a cooler climate, and a domestic currency that is anticipated to weaken.

Canada's Cryptocurrency Industry

Canada is home to a cryptocurrency industry with a diverse collection of companies offering a variety of services. Veteran multinational exchanges like Binance and Coinbase have established domestic operations while there is also a myriad of exchanges that exclusively focus on servicing the Canadian market.

Canada is also home to a unique mix of Bitcoin miners. Publicly traded mining companies Bitfarms, Hive Blockchain, and Hut8 Mining are all listed in the country and have domestic operations. Argo Blockchain has domestic operations but is listed in the UK. The Toronto Venture Stock Exchange (TSXV) has been a popular venue for companies with cryptocurrency activities to list. The less stringent listing process and less onerous reporting requirements have made the exchange an attractive route to the public markets.

Several provinces across the country have both on-grid miners and off-grid miners. On-grid mining can present various challenges, as will be detailed in both the regulatory and electricity markets sections. Off-grid mining can be more favorable but the scalability of such operations is limited. Moreover, off-grid mining can also be subject to regulations, but to a lesser extent than on-grid mining. Securing electricity and the necessary real estate are among the major difficulties facing on-grid mining. As a result, some industrial miners like Hive Blockchain and Argo Blockchain have executed deals with GPU.one to secure the necessary infrastructure. GPU.one specializes in developing Canadian data centers and has entered into both acquisition agreements and colocation agreements with Canadian Bitcoin miners. [107, 108]

Several Canadian companies have emerged with specific imperatives that are related to broader trends in the industry. Establishing initiatives and operations around environmental, social, and governance (ESG) standards have become increasingly common. For instance, Argo Blockchain announced that the company has been actively searching for strategies to be climate-friendly [109]. Argo Blockchain has stated that their Texas mining facility will be mostly powered by renewables [37]. In partnership with DMG Blockchain, Argo Blockchain also announced plans for a mining pool powered by renewable energy sources [110]. Two other exchange-listed Canadian companies, Link Global and Neptune, recently announced a joint venture to establish a 5 MW operation in Alberta that would mostly be powered by renewable energy sources [111].

Such announcements are part of a broader trend where North American companies are promoting their ESG efforts. However, it is important to note that such ventures will not be exclusively powered by renewable energy sources. The Argo Blockchain and DMG Blockchain pool, Terra Pool, will initially consist of hashrate from the operations of Argo Blockchain and DMG Blockchain. However, given that these miners have facilities that are connected to the grid, the power behind their operations will be a mixture that includes at least some fossil fuels. Moreover, the joint venture by Link Global and Neptune notes that it will utilize "solar, wind, and minimal natural gas" [111].

DMG Blockchain has also been pursuing specific imperatives with their other products. In October 2020, Blockseer, a DMG subsidiary, announced a Bitcoin mining pool that will not append any blocks that include transactions that are not compliant with guidelines set by the US Office of Foreign Assets Control (OFAC) [112].

Canada is home to cryptocurrency ASIC manufacturer ePIC Blockchain. Based in Toronto, ePIC Blockchain offers ASIC mining machines for the Siacoin network. The company recently raised $7.5 million in a Series A, aiming to expand its offerings to include ASICs for one of the top ten cryptocurrency by market capitalization [113]. The company has no immediate plans to manufacture Bitcoin ASICs.

Larger-scale mining companies are more uncommon in Canada due to the bureaucratic environment which will be further detailed in later sections. The larger-scale operations that do exist are primarily exchange-listed companies. In terms of larger-scale facilities that are not publicly traded, Blockstream has a facility in Quebec. They have since expanded their operations in the state of Georgia [114]. Samson Mow, Chief Strategy Officer at Blockstream, noted that Blockstream chose to expand in the US due to Hydro-Quebec, the utility servicing the Quebec, being challenging to deal with. Several small-scale mining-focused companies have been developing innovative solutions for the industry.

MintGreen, a startup based in British Columbia, has been experimenting with repurposing the heat from Bitcoin mining machines for industrial processes.

One of the longer-standing innovative mining-focused companies in Canada and North America overall is Upstream Data. Founded in 2017, Upstream Data has been working with oil and gas producers to offer infrastructure solutions that redirect the natural gas that is produced as a byproduct of oil drilling to mine Bitcoin off-grid. They are heavily focused on the Alberta market where oil and gas producers can be penalized heavily for their emissions. Upstream Data founder Steve Barbour was a pioneer of this field. Overall, the concept has gained greater traction in recent years with US companies like Great American Mining and Crusoe Energy also becoming involved in such activities. Another TSXV-listed Canadian company, Fortress Technologies, recently announced that it will explore utilizing stranded energy from oil fields to mine Bitcoin with Great American Mining [115]. In their announcement, Fortress Technologies noted that they "believed the future of institutional-backed Bitcoin mining would be environmentally conscious" [115].

Electricity Markets – Inexpensive Power Prices Meet Scalability Restrictions

Similar to the United States, the electricity markets in Canada consist of both regulated markets where publicly-owned utilities hold a monopoly and deregulated competitive markets where ISOs are responsible for ensuring that the demand for energy is met with preferable power sources. Alberta, Ontario, and New Brunswick operate as independent ISOs. Alberta is a particularly pertinent market for miners and has been often compared to Texas due to the prominence of its energy sector along with other comparables between the two. The region produces roughly 13% of Canada's electricity generation, with 91% being derived from fossil fuels [116]. A myriad of opportunities to source low-cost power exist across the province, with it being advantageous for energy producers in remote regions to offload their energy to a local consumer rather than transmit it at a discounted rate to distant consumer hubs or outside of the province.

The electricity markets for the remainder of Candian provinces function as regulated utility markets with each province having its own electricity policy and regulatory agency. Based on the specific policies in each province, it will be more or less favorable to Bitcoin mining businesses. The regulatory risks will be discussed in further detail in the regulatory section. Quebec, Manitoba, British Columbia, and Newfoundland and Labrador are notable regulated markets, due to the large share of energy production attributable to hydropower in these provinces. Miners operating within these provinces are typically connected to the grid and powered by an energy mix that is predominantly hydropower. Among the regulated provinces, Quebec is particularly noteworthy, with several exchange-listed mining companies like Bitfarms, Hive Blockchain, and Argo Blockchain having large-scale operations within the province. Saskatchewan is a regulated market where 83% of electricity production is derived from fossil fuels [117]. Miners operating in this province will be mostly powered by natural gas, with 43% of the province's electricity production coming from natural gas, and 40% coming from coal which is being progressively phased out.

Similar to the US, an abundance of energy production provides the possibility to source low-cost power in localized regions where energy production is distant from consumption sources. Canada is a major exporter of energy, both interprovincially and to the US. In 2018, Canada exported 52 TWh of energy to the US, roughly equivalent to the annual energy consumption of Greece [62, 118]. The reality of sourcing energy in Canada varies widely depending on the circumstances. Data from the World Bank suggests that Canada is a relatively difficult country for sourcing electricity. In the World Bank "Ease of Doing Business rankings", Canada ranked 124th out of 190 countries for "getting electricity". For comparison, the US ranked 64th [98].

Canadian miners can source electricity through a mixture of methods. In regulated markets, the typical way to source electricity is directly from the utility company that serves the market. In this case, miners typically secure the same power price as large-scale industrial consumers. For Quebec, serviced by the utility Hydro-Quebec, this rate is approximately $0.039 USD per

kWh. Some industrial consumers in Quebec secure rates as low as $0.0248 USD per kWh but the price for cryptocurrency miners is widely reported to be ~$0.039 USD per kWh [119]. In British Columbia, the rate is approximately $0.054 USD per kWh. Such power prices may have been among the most competitive industry-wide when many Canadian miners were initially establishing operations in 2017 and beforehand. However, the accelerated industrialization of Bitcoin mining since the significant BTC price appreciation of 2017 has radically reduced the competitiveness of such electricity rates. July 2020 research by BitOoda suggests that miners operating at power prices above $0.035 per kWh are among the 30% least efficient miners from a power price perspective [8].

There are possible avenues for Bitcoin miners to reduce their electricity prices in these regulated markets. However, the majority of large-scale consumers will secure the same industrial rate. One route to reducing the power price in these regulated markets is securing economic development discounts. A large percentage of the power generated in hydropower-prominent provinces like Quebec, Manitoba, and Newfoundland and Labrador is not being sold locally. As a result, utilities are incurring high transmission costs to transport this energy to trading partners like the Northeastern states of the US. Utilities can generate greater revenue by selling this energy locally. As a result, it is possible to secure discounts on base power prices in some areas. In some sparsely populated regions with significant energy production, in provinces like Newfoundland and Labrador, there have been reports of some miners securing power prices of less than $0.01 per kWh USD. Oftentimes, these regions can also be preferable to reducing CapEx as they may have vacant real estate nearby energy producers that can be leased cheaply. However, it has been noted by a Hydro-Quebec VP that finding land and real estate opportunities nearby power supply can be challenging [119]. The scalability of such operations is also questionable, which will be detailed further below.

Another avenue to sourcing lower-cost power in regulated Canadian electricity markets is sourcing from independent power producers (IPPs). While the provincial and municipal governments own the majority of power-related infrastructure in the regulated markets, the private sector does own some of the infrastructure. This can be as little as 2% of the overall infrastructure in some regulated provinces like Manitoba [120]. IPPs can operate in regulated utility markets and can sell their production to distribution companies, controlled by the state-owned utility, or industrial consumers. However, it has been noted that IPPs rarely sell to industrial consumers [120]. IPPs typically hold long-term contracts with utility companies and it rarely makes sense for them to enter agreements with other customers. Among regulated markets, Quebec is likely to be the largest in terms of hashrate production. It is home to the operations of several exchange-listed miners. Newfoundland and Labrador and Manitoba are also believed to have significant energy capacity dedicated to Bitcoin mining. The industry in British Columbia is believed to be small in comparison. DMG Blockchain is one of the few publicly-known miners in British Columbia with facilities in Christina Lake and Trail [121].

In unregulated markets, there are also a variety of methods that miners can choose to source energy. The Alberta market is particularly relevant for Bitcoin miners. Sourcing directly from the Alberta Electric System Operator (AESO), the Alberta ISO, can oftentimes be costly due to high transmissions costs integrated into the ultimate cost of power. Nonetheless, there remain localized regions where miners can source inexpensive power. There are reports of several miners in Alberta sourcing electricity for as low as $0.015 per kWh USD. It is also possible for consumers in the AESO market to avoid transmission costs and reduce their ultimate power price by participating in demand-response programs. However, compared to the Texas ERCOT market, effectively participating in such programs is more difficult and less lucrative. For instance, to avoid transmission line charges in the ERCOT market, consumers can participate in the 4CP program where they curtail their energy consumption during 15 minutes of peak demand in each of the four summer months. The peaks in demand are easily forecasted and easy to avoid. However, in the AESO market, this program is the 12CP program and runs year-round. Forecasting the peaks in demand is also more difficult [122]. The ability to procure inexpensive power from the AESO will heavily depend on a miner's ability to identify a region with low-cost power within the market. The location-agnostic nature of mining businesses is favorable to establishing operations in such regions. However, any Canadian miner connected to the grid runs the

risk of their additional costs being imposed as a result of the bureaucratic regulatory environment. This will be further detailed in the following section.

Sourcing directly from the ISO is not the only option available to companies within ISO markets. In deregulated markets, miners can also source electricity behind-the-fence. They can work towards building a vertically integrated structure where they own the power generation infrastructure. These options can radically reduce power costs as it avoids the high transmission costs and additional costs that are imposed by the ISOs. However, the AESO can intervene in behind-the-fence operations if they're not structured according to their policies. If power producers generate in certain parts of the province, they may have an obligation to sell some of the energy back to the grid or interprovincially. Such policies can be observed throughout the Canadian electricity markets. This puts a limit on scalability and is one of the key reasons why ambitions of 100 MW+ mining facilities never surface in Canada.

An abundance of opportunities to utilize stranded energy to mine Bitcoin also exist in Canada. We previously noted that it is advantageous for energy producers in remote regions to sell locally to Bitcoin miners rather than transmit over long distances at a discounted rate. Oil and gas producers have an even stronger incentive to consider Bitcoin miners as a customer. Oil and gas producers, who represent a significant share of the energy production in both Alberta and Saskatchewan, face significant expenses related to regulation. They can be penalized heavily for the emissions they release. Utilizing the natural gas to power Bitcoin mining becomes an extremely attractive alternative in the face of such costs. Upstream Data specializes in offering mobile containers and power generators that enable oil and gas producers to utilize the natural gas for Bitcoin mining. Upstream Data has focused heavily on the Alberta market.

For new entrants, sourcing energy through the grid can be a significant challenge. World Bank data highlights that Canada is a difficult environment for sourcing electricity [98]. In a regulated market, Bitcoin miners must secure energy from the utility or an IPP which can be a lengthy and arduous process. Once power is secured, data suggests that acquiring the same power price as industrial consumers in a regulated market would place miners among the 30% least efficient from a power price perspective [8]. There are incidents where miners can source inexpensive power in localized areas where extremely inexpensive power prices can be secured. However, scalability is a question in these markets and securing appropriate real estate can also be a challenge [119]. Off-grid mining in a deregulated market emerges as the most favorable to securing inexpensive power but it is also limited in terms of scalability. Regardless of how Candian miners source energy, regulatory risks have the potential to evolve into a significant burden.

Canada's Bureaucratic Regulatory Environment

Canadian miners operate in an extremely bureaucratic regulatory environment. Compared to the US, there is a higher possibility that either the federal government, provincial governments, or municipal governments could introduce changes that are unfavorable to Bitcoin mining businesses. In addition to this, there is a myriad of regulatory bodies and agencies spread across the country that could impose restrictions on Bitcoin mining activity. There is also a lack of clarity regarding how Bitcoin mining and other cryptocurrency-related business activities should be treated. Each province has their own securities regulator, which may deviate in its stance on how certain activities should be treated, further complicating matters. The complex regulatory environment has previously prevented other cryptocurrency businesses from establishing operations in the country. In 2015, it was speculated that the complex regulations in the country were delaying Coinbase's aim to establish domestic operations [123]. Even after establishing operations in the country, Coinbase imposes some restrictions on Canadians and limits them to more costly trading options [124]. The extremely bureaucratic regulatory environment is another reason why Canada is more unfavorable to large-scale mining, compared to the US. Generally, the larger an operation is, the more potential there is for a regulatory body or government to impose unfavorable changes on the entity.

For instance, on the federal level, the recent introduction of the carbon tax will raise costs for almost all consumers that are sourcing energy in front of the meter. Starting January 1st 2019, the Canadian government introduced a country-wide carbon tax minimum that applied to all provinces that didn't already have their own carbon tax plans in place [125]. The carbon price was initially set at $20 CAD per metric ton [125]. It rose to $40 CAD in April 2021 [126]. The federally-imposed minimum will reach $50 CAD per metric ton by 2022 and $170 CAD per metric ton by 2030 [127]. Industrial consumers will be subject to a different pricing mechanism [128]. Each province has their own unique plans to meet these targets. The carbon tax will be particularly pertinent for on-grid miners that are sourcing power from fossil fuel-intensive power mixes in states like Saskatchewan and Alberta. While the government outline aims to increase the tax to $170 CAD by 2030, the federal government holds the power to impose a tax that is even greater than this figure.

The provincial governments of Alberta, Saskatchewan, and Ontario have unsuccessfully challenged the carbon tax. The Canadian Supreme Court recently ruled that the federal government's carbon tax introduction is constitutional [127]. In the US, a federally imposed carbon tax is opposed as Republicans in Congress have repeatedly voted to stop the government from introducing one [127]. Some regions in the US have unfavorably treated Bitcoin miners by raising electricity rates. For instance, one region within Washington state hiked rates for Bitcoin miners [129]. In 2016, the utility serving Wenatchee proposed a rate hike on consumers with a power density of over 250 kW per square foot, a power usage that is surpassed by Bitcoin mining but rarely surpassed by data centers [130]. Moreover, the utility put in place a moratorium for power requests of 1 MW and over. However, a state-wide imposition of such rate hikes and moratoriums would be outside the realm of reasonable possibilities. However, for Canada, the risk of unfavorable changes targeted at the Bitcoin mining industry on the federal, provincial, and local level is much higher. This was evident from a moratorium imposed by Hydro-Quebec in 2018.

In March 2018, after significant energy requests from cryptocurrency miners, Hydro-Quebec imposed a moratorium on new power requests from the industry [131]. They also sought to introduce an industry-specific rate for cryptocurrency miners [132]. However, the proposal for an industry-specific rate was rejected by the energy regulator of the province, the Régie de l'Énergie. These regulatory developments presented challenges to existing miners in the region that were seeking to expand operations and prevented new players from entering. Miners who had already invested in hardware and real estate were left facing huge costs [131]. Bitmain was also considering establishing large-scale operations in Quebec in 2018 [119]. However, the moratorium prevented new power requests from being processed and the sudden change in regulation made the province significantly less appealing. Bitfarms have since successfully expanded in the province [133]. However, both Bitfarms and Argo Blockchain have also been considering overseas regions for expansion. Bitfarms is exploring opportunities in South America while Argo Blockchain is expanding in Texas [134].

In late 2019, a business manager at the British Columbia utility BC Hydro outlined intentions to introduce a discounted electricity rate for cryptocurrency mining companies [135]. However, such intentions never materialized and criticism from the public may have played a role in stopping such developments. An economics professor at the University of British Columbia argued that "We really want to create jobs and create economic activity and benefit communities, and it's far from clear that is the case with bitcoin operations because they employ very few people, and basically all the benefits go to those companies." [135]

In addition to the myriad of regulatory bodies and extremely bureaucratic environment, a lack of clarity regarding cryptocurrency mining and cryptocurrency assets exacerbates matters for Canadian cryptocurrency companies. Regulators have failed to transparently classify different types of cryptocurrency assets and how they should be treated. The Canadian Securities Administrators (CSA) have stated that they consider "many" initial token offerings to be securities offerings [136].

The guidelines that are currently being proposed may significantly raise the costs for companies in the industry and could stifle growth in the Candian ecosystem. On March 29th, the CSA issued guidelines that platforms facilitating the trade of digital assets must register as investment dealers and become members of the

Investment Industry Regulatory Organization of Canada (IIROC) [137]. The CSA chair noted that the next steps for platforms will be reaching out to their local securities regulators to find out what regulations apply to their business [138]. Moreover, the Ontario Securities Commission imposed a deadline of the 19th of April for trading platforms that service Ontario residents to reach out about regulatory requirements. Complying with such regulations will be costly. Lari Stein, a partner at law firm Osler, Hoskin & Harcourt LLP, noted that it will be "costly and time-consuming for platforms to achieve regulatory compliance under this framework" [137]. Becoming a member of the IIROC may impose requirements that make it infeasible for smaller-scale startups to begin offering cryptocurrency trading services [138]. Strict requirements include having audited financial statements, minimum regulatory capital, insurance, and a chief compliance officer with relevant certification.

Overall, the fragmented and bureaucratic regulatory environment of Canada represents a significant risk to new entrants and could impose costs that threaten the longevity of businesses. For miners, the myriad of regulatory bodies and governments that could impact their business with a change of stance makes the environment more suitable for smaller-scale mining operations. In many cases, sourcing behind-the-fence will also be preferable as it will help miners avoid the bureaucracy relating to grid usage. For non-mining related cryptocurrency businesses, the environment may be more suitable for large-scale businesses. Recent developments suggest that regulators will impose costly compliance requirements that only large-scale enterprises with sufficient resources will be able to meet. Such a trend is further corroborated by a diverse and large collection of companies with cryptocurrency-related activities trading on the Canadian capital markets.

An Easier Route to the Public Markets

Canada's capital markets are immensely outsized by the size of the US capital markets. However, they offer certain advantages to cryptocurrency companies, including less stringent listing requirements and financial reporting standards for some exchanges. Canada's largest stock exchange, the Toronto Stock Exchange (TSX), has a market capitalization of roughly $2.62 trillion [139]. By comparison, the S&P 500, has a market capitalization of over $32 trillion, over twelve times greater than the size of the TSX [140]. However, exchanges like the Toronto Venture Stock Exchange (TSXV) and the NEO Exchange provide companies with a less onerous route to listing publicly, compared to major exchanges like the NASDAQ and TSX, and less costly requirements upon listing.

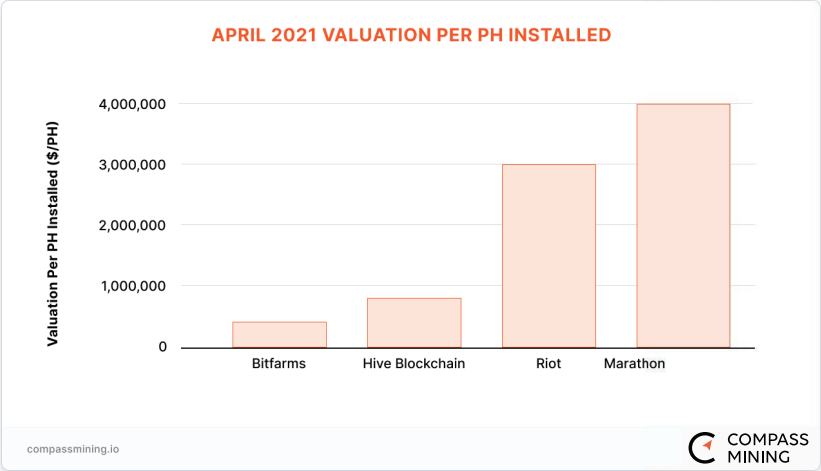
The TSXV has been a popular venue for Canadian cryptocurrency companies. Bitfarms, Hive Blockchain, and DMG Blockchain are all trading on the exchange. There are several ways to list on the TSXV. Companies can carry out an IPO process which is estimated to take roughly 16-20 weeks [141]. This is the traditional route to listing on a stock exchange. The Ontario Securities Commission (OSC) takes the lead in approving such applications, with the exchange itself being a secondary approver. Bitfarms carried out this process and listed on the TSXV in July 2019.

Another popular listing option is a reverse takeover, whereby a company already listed on the TSXV is acquired. Hive Blockchain pursued this option to listing with a reverse takeover of Leeta Gold Corp in September 2017, making the company the first cryptocurrency mining company to list on the TSXV [142]. With reverse takeovers, the exchange is the primary approver with the OSC being a secondary approver. The estimated cost of listing on the TSXV, including listing, accounting, and legal fees, varies widely [143]. It is estimated to range from $110,000 CAD to over $300,000 CAD exclusive of an underwriter's commission that can go up to 12% [143]. The ultimate costs and commission will depend on the specifics of the company. For comparison, the TSX estimated costs range from $485,000 CAD to $1,050,000 CAD with an underwriter's commission of 4% to 8% [143].

Upon listing, companies can access the broader benefits of the public markets. There is liquidity for shareholders in the company and the company can also choose to raise capital. In 2019, $43 billion was collec-

tively raised by companies listed on the TSX and TSXV [144]. Canadian exchange-listed companies tend to raise capital through private placements whereas at-the-market equity offerings are more common among US-listed companies. TSXV listed companies have less stringent reporting requirements, compared to the TSX. TSXV-listed companies have 120 days to report year-end earnings, compared to 90 days for TSX-listed companies. For quarterly reports, TSXV-listed companies have 60 days to report whereas TSX companies have 45 days. Moreover, TSXV companies can operate without an audit committee whereas TSX companies are required to have one. Overall, the listing process is easier and the financial reporting requirements are less costly for TSXV listed companies.

In the US chapter, we noted the extremely high valuations that US companies trade at on both a value per installed PH and a value per future PH basis. Canadian mining companies trade at much lower valuation multiples than their US counterparts. In April 2021, Bitfarms and Hive Blockchain were trading at $385k per PH installed and $800k per PH installed respectively [36]. For comparison, Marathon and Riot Blockchain were trading at $3.99 million and $2.99 million per PH installed. Such high valuations can be advantageous for companies. For instance, Argo Blockchain was able to pay for its Texas expansion by issuing and alloting shares to the seller of the 320-acre land plot with access to 800 MW of power [146].



The loftier valuations that US mining companies are trading at provides a strong incentive for Canadian companies to pursue a dual listing on the NASDAQ. Bitfarms and Hive Blockchain are currently both exploring dual listings on the NASDAQ [147, 148]. The path of listing initially on the TSXV and afterwards pursuing a dual NASDAQ listing could prove to be an extremely attractive route for mining companies. Companies can benefit from the less onerous and costly listing process while also being able to access greater valuations if they can accomplish a NASDAQ dual listing. 2021 will be revealing regarding the concept of a dual listing. It will highlight the difficulty mining companies face when pursuing a dual listing and will also give some indication of whether companies that trade on both the NASDAQ and the TSXV trade at a valuation multiple discount compared to those that solely trade on the NASDAQ.

Canadian regulators recently began approving Bitcoin exchange-traded funds (ETFs), consistent with the nature of the Canadian markets catering to assets of a higher risk profile. Investors have been awaiting a Bitcoin ETF since 2017 with several applications being rejected by US regulators. In March, Canadian regulators approved the Purpose Bitcoin ETF, the Galaxy Digital

Bitcoin Trust, and the Evolve Bitcoin ETF. The assets under management within the ETFs quickly grew throughout the month, surpassing the $1 billion mark by roughly the middle of March [149].

Mining companies listing in Canada years before US listings and the approval of Bitcoin ETFs in Canada after several rejections within the US may be indicative of a persisting trend in the capital markets of the US and Canada. Canada may serve as a testing ground for cryptocurrency activities that, once established, will be more likely to proliferate in the US. Bitfarms, Hive Blockchain, and Hut8 preceded the emergence of Marathon and Riot Blockchain. Both Marathon and Riot trade at vastly higher multiples, primarily due to the bigger scale of the US capital markets. It will likely only be a matter of time before we observe US Bitcoin ETF approvals following the recent Bitcoin ETF approvals in Canada. Once a US Bitcoin ETF is approved, it will likely observe a greater inflow of capital compared to the Canadian ETFs.

Hardware Importation, Climate Conditions, and Domestic Currency Strength

Several other factors impact the favorability of mining in Canada. The attractiveness of power prices and the bureaucratic regulatory environment are among the major considerations detailed above. However, taxes related to importing hardware, climate conditions, and the strength of the domestic currency are other factors that impact the relative attractiveness of mining in Canada compared to the US.

Importing hardware directly from China to the US incurs a 2.6% duty and a 25% tariff [150]. Canadian miners are subject to much lower import costs, placing them in a favorable CapEx position to US miners who incur the 2.6% duty and 25% tariff. Candian miners incur a 5% goods and services tax on imported hardware, significantly reducing the payback period on their CapEx compared to a miner who is paying a 27.6% additional cost on their hardware. Moreover, Canadian corporations with a goods and services tax number can apply for a refund of the tax with the Canada Revenue Agency afterwards.

Climate is another factor that can provide more favorable conditions for mining in Canada compared to certain regions in the US. The cool climate conditions make mining machines less susceptible to overheating and can lengthen the hardware lifespan. With more miners experimenting with innovations like immersion cooling, climate conditions may become a less relevant factor. However, many mining companies are not experimenting with sophisticated heat management solutions. In this case, climate becomes a more pertinent factor. However, there is also the risk of facilities being subject to excessively cold temperatures that can damage facilities and mining equipment [151].

The strength of the Canadian Dollar will also impact the relative attractiveness of mining in Canada. Research issued by The Conference Board of Canada suggests that the Candian economy may struggle in the aftermath of the COVID-19 pandemic [152]. The Candian federal and provincial governments alleviated the economic crisis imposed by COVID through stimulus measures. While such measures provided immediate assistance to households and businesses, the stimulus has also exacerbated Canada's trade deficit and added significantly to public debt. Net debt to GDP is anticipated to rise to 95% over the coming years. These levels were last observed in the early 1990s which was followed by roughly a decade of the Canadian Dollar depreciating versus the USD [153, 154].

The strength of a domestic currency impacts the effective profitability of Bitcoin mining operations. If a period of a weakening CAD ensues, it will effectively widen the margins of Canadian miners who have fixed their costs in CAD. How the strength of the Canadian Dollar will unfold is uncertain. However, with some analysts anticipating a weakening CAD in the aftermath of the crisis, such an event would improve the operating conditions for Candian miners across the country.

Chapter 3 Summary

When all the factors relating to mining in Canada are explored, a clear picture begins to emerge. The bureaucratic regulatory environment is largely unfavorable to large-scale Bitcoin mining operations. Although some players are successfully operating and expanding large-scale operations in Canada, there are significant risks associated with doing so. For smaller-scale operations, the possibility of securing extremely inexpensive power prices exists. Reports surfaced of several miners operating at $0.015 per kWh and below. There is also an abundance of opportunities to utilize stranded energy to mine Bitcoin. Oil and gas producers face significant costs related to their emissions and have a significant opportunity to explore alternative methods of utilizing this energy. As a prospective mining region, Canada holds both advantages and disadvantages compared to the US. Lower hardware import costs, a cooler climate, and an anticipated weakening Canadian Dollar are factors that could provide relatively attractive conditions but miners with ambitions of large-scale facilities are better served considering the US.

Conclusion

Technology trends are dynamic and constantly evolving. Capital markets, innovation, and human interaction all impact how the industries built around disruptive technologies change and adapt. Bitcoin mining is no different. We have already observed significant shifts in how the industry is structured.

After the introduction of Bitcoin ASIC manufacturing in 2013, China claimed a firm foothold on the industry. Mining pools, service providers, and hashrate production naturally burgeoned around the centre of ASIC production. The dominant share of the industry residing in China would have a self-reinforcing effect over the following years with mining-related startups and operations continuing to spawn within Chinese borders.

China still maintains its dominance but its share of the industry has been diminishing in recent years. North America has been accounting for a greater portion of hashrate production and a diverse assortment of companies have emerged to cater to the growing US mining industry. Developments like a vastly greater block rewards market, longer hardware lifecycles, and more recognition for Bitcoin as a legitimate asset class have all played a role in this growth. These developments have changed the relative attractiveness of mining in China compared to North America.

As the Bitcoin mining industry continues to evolve, the nature of the industry will undoubtedly continue to change. As detailed in this report, there are factors that suggest North America will displace China as the leading Bitcoin mining industry worldwide. More intense competition for year-round inexpensive power prices, a higher degree of jurisdictional certainty, and greater access to cheap capital have all acted as forces that have increased North America's share of the industry. As the image of Bitcoin continues to transition away from that of a high-risk speculative asset to one of a legitimate asset class, the imperative to establish long-lasting Bitcoin mining operations will become commonplace. North American miners have strongly exhibited that they wish to do just that. Many of the miners interviewed demonstrated that they're seeking to establish their structure in a way that ensures their operations and business can sustain its competitive advantage for multiple decades.

Several industry professionals anticipate that it is only a matter of time before the North American Bitcoin mining industry surpasses the scale of the industry in China. This may seem to be an attempt at prescience. But it may simply be an acknowledgement of the relative advantages of Bitcoin mining in North America, the changing nature of the industry with hardware supply limitations becoming a less restrictive factor, and North American miners ambitions of establishing operations with multi-decade outlooks.

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