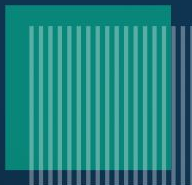


Issue 1  
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# BITFINEX Alpha



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# Bitfinex Alpha | ISSUE 1

Thought leadership | Research | Market Analysis

Welcome to Issue 1 of Bitfinex Alpha, an initiative of Bitfinex that provides an in-depth analysis of various topics surrounding cryptocurrency and blockchain. We aim to give our users a more profound insight into the industry through mind-opening subjects and analysis created by industry leaders in the blockchain and FinTech industries.

For a long time, Bitcoin's energy requirement in its creation process has been a subject of contradiction, even within the crypto community itself.

But, what if Bitcoin's creation process generates not only Bitcoin but also global markets, such as electricity?

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Whether you are a Bitcoin miner or a holder, we believe you will get valuable insight from our collaboration with a fintech and crypto researcher, John Dwyer for the first issue of Bitfinex Alpha.

John Dwyer is a contractor for Bitfinex where he provides crypto research services. He first bought Bitcoin in 2013 and invested in the Ethereum financing in July 2014.

Previously he was Global Digital Assets Research Lead at Celent (the fintech research division of Oliver Wyman). This followed a career in investment banking where he ran equity capital markets businesses at Macquarie Capital (specializing in natural resources) and Goldman Sachs.

**The views and opinions expressed in the note belong solely to the author and do not reflect those of Bitfinex.**

# Bitlectricity

Bitcoin as the Unit of Account for Electricity

*By John Dwyer*

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# Part One

## Mining Finance (MiFi)

**Bitcoin fuses technology, energy, and money in a manner which was not previously possible.**

Bitcoin mining is the process of adding transaction records to the Bitcoin blockchain. It is a record-keeping process requiring immense ongoing computing power whereby each miner contributes to the decentralized peer-to-peer network ensuring the network is trustworthy and secure. Miners take energy, time, and mining hardware as inputs and create digital scarcity in the form of Bitcoin.

The topic of mining has been covered extensively elsewhere and so we will only focus on it at a high level in this report. The implications for global energy and electricity markets is the focus.

### **Proof of Work – Creates Hard Money**

Adding blocks to the ledger is facilitated by so-called Proof of Work (PoW) based on the SHA-256 algorithm that miners run. **Miners incur expensive processing power** to solve complicated mathematical problems which are hard to solve but easy to verify. Miners costs are predominantly mining rig hardware (capex) and electricity (opex).



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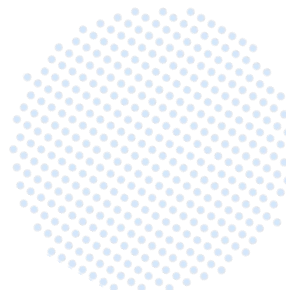
## Mining Reward

The miner that produces the new block earns a reward which is currently 6.25 new Bitcoins. This is the financial incentive for miners to incur the financial cost of mining. In effect, profitable miners are those that can sell the Bitcoin they mine at a profit to their cost of mining it.



## The Difficulty Adjustment – Predictable Bitcoin Monetary Policy

Hash rate is the measuring unit of the processing power of the Bitcoin network. As the hash rate increases/decreases, this impacts the pace at which the PoW problems are solved thus accelerating/decelerating the rate of production of new blocks of transactions.



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To compensate, the network has an in-built difficult adjustment which means that the computing power necessary to solve the PoW problems adjusts every 2016 blocks in response to changes in the aggregate mining hash rate. The result is that the network is self-correcting, approximately every two weeks, ensuring that new blocks are created approximately every 10 minutes.

**In short, the Bitcoin network combines time, energy, and mining hardware to create Bitcoin**



2016 blocks at approximately 10 minutes per block is 20,160 minutes which equates to 14 days

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# Bitcoin mining returns



Bitcoin miners think about returns in two ways.

i. **Cash flow breakeven:** this is when cashflow covers operating expenses (opex). Miners sell the Bitcoin they earn at a price in fiat that they do not control. If this cash inflow falls below their opex then the economically rational decision for the miner is to shut down their mining rigs.

It is assumed that Bitcoin miners can instantly shut down mining operations. However, this decision is impacted by the agreement they have with their energy provider which may stipulate a minimum quantity of energy must be taken by the miner over a given time-period. This has caused certain miners to operate unprofitably at sub cashflow breakeven levels.

Therefore, **miners are incentivized to source the cheapest energy and optimize flexibility with respect to the usage of the energy.**

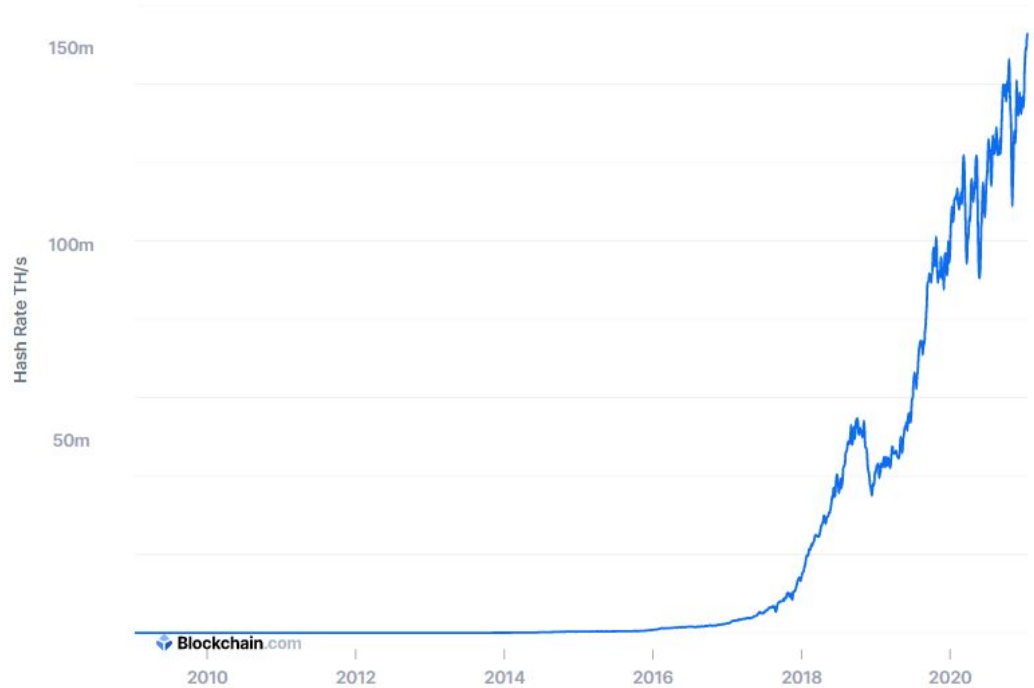
ii. **Return on Investment (ROI) breakeven:** this is when cashflow covers both opex and capital expenditure (capex) on the mining rigs/hardware. The higher the ROI then the higher the profitability of the mining operation.

The key drivers of ROI are the miner's cost of electricity and the cost of their mining hardware (and thus the depreciation schedule of that hardware).



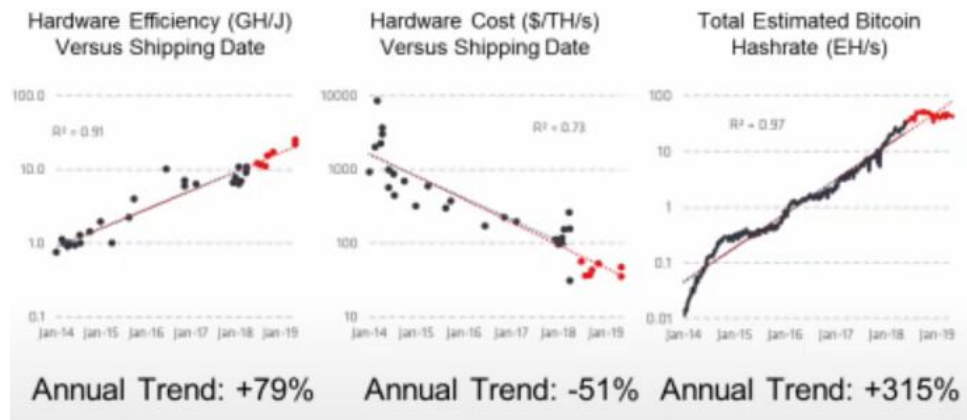
## Hash Rate Trends

Bitcoin's hash rate is currently estimated at 150mn terahashes (TH) per second where 1 TH equates to one trillion hashes per second. Mining hash rate is a key security metric as the greater the hashing (computer) power in the network then the greater is the security of the Bitcoin network.



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The efficiency of mining hardware has improved consistently since the industrialization of Bitcoin mining which commenced around 2014. Data from Coinshares demonstrates that the efficiency of mining rigs has grown consistently whilst the cost (on a \$ per TH basis) has fallen. The combination of this growing efficiency and reduced cost has driven strong growth in the hashing (computing) power generated by the total Bitcoin network.



### ASICs – Specialist Hardware

Bitcoin mining has evolved from CPUs (central processing units) to GPUs (graphics processing units) to ASICs (application-specific integrated circuits).

ASICs are highly specialized chips which are optimized for the single purpose of Bitcoin mining thus are more energy efficient than GPUs or CPUs and can be deployed into small and mobile connected devices. However, they lack an alternative use other than mining.

**The pace of innovation in ASIC design means they have a high rate of depreciation and low residual economic value.** This has implications for the financial returns generated by miners.

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## The Key Variables Driving Bitcoin Mining Returns



- **Bitcoin price** –Bitcoin is a synthetic product, so Bitcoin miners are exposed to price risk on Bitcoin which is their primary revenue driver. A miner's theoretical reward complies with the law of large numbers and is proportional to its computing power as a percentage of the total computing power on the Bitcoin network. Therefore, investing at scale in mining hardware and electricity agreements to run **a mining operation equates to a synthetic long position in Bitcoin.**
- **Transaction fees** –Miners also earn transaction fees, the level of which correlates positively with activity on the network. As the network matures, transaction fees are expected to increase.
- **Difficulty adjustment** –The difficulty adjustment creates uncertainty for a miner as to how many Bitcoins will be mined over a given future time-period. The difficulty adjustment is positively correlated with the total computing power of the entire network.
- **Electricity prices** – electricity prices are the key driver of opex.
- **Hardware prices**– hardware capex drives upfront cash investment and depreciation. The depreciation of ASICs (and their lack of alternative use) means that **the depreciation charge is analogous to the premium paid for a call option and time decay.** The cost of electricity prices can have a material impact on the time decay and profitability of mining hardware

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## Managing Miners' Risk

Hash rate derivatives have emerged to assist miners with managing risk of total hash power, the difficulty adjustment, and Bitcoin's price volatility —this is a key area of growth in the years ahead.

Electricity prices (opex) and hardware purchase prices (capex) are the main two variables which a miner can control. Mining hardware production remains relatively centralized although, like any hardware, it is becoming more commoditized, smaller, and cheaper.

Therefore, the outlook for mining is that sourcing the lowest cost electricity is the main driver for successful miners. In addition to lower opex (and improved profitability) it also offsets the lower energy efficiency of older mining rigs. Lower energy costs offers miners the option of investing in older, cheaper mining hardware and still achieving a positive ROI.



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## Mining Finance – ‘MiFi’

Previously we have highlighted that **hash power will be recognized as a new asset class along with Bitcoin**. Bitcoin mining is essential to the future of Bitcoin and will attract large and growing amounts of financial capital from traditional markets and institutional investors.

The traditional fixed income asset class faces challenges from low/negative nominal interest rates and central bank intervention. **Mining Finance (or “MiFi”) offers a new asset class for institutional capital to be deployed across the capital structure into assets which can earn a probabilistic-based yield from Bitcoin mining.**



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# Part Two

Two areas attracting growing interest from the Bitcoin community relate to electricity and renewable energy. We consider each in turn examining the legacy challenges these markets face.

## Electricity

Electricity cannot be stored efficiently or cheaply.

If we think of electricity as a commodity, then this is a unique attribute relative to other commodities and it inhibits the applicability of modern financial asset pricing theory to electricity markets and the effective arbitrage of spot and derivative markets. Therefore, electricity markets have certain traits.

### **Negative Prices for Electricity**

Firstly, **electricity spot markets can be volatile and experience negative prices**<sup>2</sup>. Negative electricity prices occur when a power generator, with little operational flexibility, continues to generate surplus power during periods of low electricity demand. The reasons for such operational inflexibility can be technical in nature, contractual (a legal obligation to provide a contracted level of balancing power to the grid), or financial (there are costs associated with shutting down/ramping up a power plant).

### **Electricity is a Localized Market**

Secondly, **electricity is a *localized* market** as an electricity deficit in one geography/market cannot necessarily be satisfied by a surplus in another geography/market due to the challenges associated with storage and transportation of electricity. **An international homogeneous electricity market does not exist – rather there are multiple discrete electricity markets around the globe.**

<sup>2</sup> <https://energypost.eu/negative-electricity-prices-lockdowns-demand-slump-exposes-inflexibility-of-german-power/>

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## Complex Microstructure

Thirdly, the combination of lack of storage and lack of flexibility of power generation assets creates complex market **microstructures in electricity markets driven by the need for ongoing real-time equilibrium between energy generation and energy consumption.** These microstructures typically feature an intraday market, a day-ahead market, and the forward market.

## Low Liquidity in Electricity Forwards

The day-ahead market (the spot market) is based on a fixed trading auction whereby participants bid/offer for a particular hour of electricity for the next day. This specificity of delivery is important and impacts liquidity across the forward curve.

Electricity forward markets share many aspects with those of storable commodities (such as coal, oil). The most important difference in electricity forward contracts from storable commodities relates to term structure. **Electricity forward contracts are highly specific** on when delivery of electricity occurs and contracts can come in different delivery classifications: baseload, peak-load, and off-peak. Consequently, **there tends to be sparse liquidity across the electricity forward curve.**

Finally, the absence of storage implies an unclear relationship between spot and forward prices by suppressing any arbitrage. Unlike other commodity markets, **participants cannot rely on convergence of electricity spot and forward prices.**

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## **Alternative Energy**

We will use the term Alternative Energy to cover renewable, trapped, and waste energy.

- Renewable energy is an energy source that does not deplete and has a marginal cost of zero.
- Trapped energy is energy which cannot be commercialized through traditional methods.
- Waste energy is a by-product of an industrial process.

### **Intermittent Energy is Bad for the Grid**

A principal feature of **renewable energy is that it is intermittent**, particularly wind and solar power. This poses a problem for the power grid as its **baseload power cannot be intermittent**. Therefore, **when supplying the power grid, renewable energy cannot operate alone** and requires energy buffering by combining it with on-demand fossil-fuel based energy (or effective energy storage).

Like all energy sources, renewable energy must be brought from where it is located to where it is consumed which requires infrastructure. If the infrastructure is not in place, then this requires upfront capital expenditure which reduces the economic feasibility of many renewable energy projects.

Bitcoin mining can mitigate both issues.

### **Plug-and-Play Infrastructure**

Firstly, the intermittent nature of renewable energy does not pose the baseload power challenges as the renewable energy is not being directed towards the grid rather it is going towards Bitcoin mining. Secondly, Bitcoin mining rigs mitigate the need to build out traditional energy infrastructure. Instead, the mobile mining rig is the infrastructure, and it is brought to the energy source.



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**Bitcoin mining inverts the traditional centralized power grid structure to create a decentralized real-time market for energy anywhere in the world.**

### **Renewables – A Highly Nuanced Area**

The topic of renewable energy is much more nuanced and complex than this though. The intermittent nature of renewable energy means greater reliance upon it for supplying traditional power grids brings the need for a proportionately larger build out of installed capacity to offset the risks of intermittency. The implications for the scale of renewable physical asset construction are significant to say the least. The production of wind turbines and photovoltaic solar panels requires a significant share of the global production of certain critical metals—a study by the Government of Netherlands highlights the extraordinary quantities of critical raw metals which will be required for renewable energy build out.<sup>6</sup>

Renewable energy also brings new challenges to existing, legacy grid infrastructure. Moreover, the American Society of Civil Engineers published a report on the state of the US electric grid stating that the transmission and distribution lines have reached or exceeded their 50-year life expectancy. This legacy infrastructure was designed to transmit power from centralized fossil fuel power plants outwards in one direction to where it is consumed.

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Renewable energy tends to be more dispersed and not unidirectional which, when combined with intermittency, creates operational challenges for maintaining voltage and frequency of the power grid within acceptable limits.

In short, **renewable energy presents certain challenges for legacy power grid infrastructure.**

### **Waste Energy**

Bitcoin mining has successfully monetized waste energy from the oil and gas industry.

Approximately 150 billion cubic meters natural gas is wasted through flaring each year. This waste is primarily driven by poor financial incentives and presents a major environmental concern.

Upstream Data is one company providing solutions to the oil and gas industry leveraging the portable plug-and-play infrastructure for Bitcoin mining. Their rigs use the vented gas as an energy source and use it to mine Bitcoin. The benefits of this are significant:

- Creates a new revenue opportunity (counter cyclical to the core business)
- Reduces capex investment (no pipelines or powerlines)
- Mitigates regulatory risk related to flaring/carbon tax liabilities
- Can reduce emissions

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## Trapped Energy

The plug and play infrastructure of Bitcoin mining is the key driver of accessing traditionally trapped energy sources as it mitigates the need for expensive, upfront capex on traditional energy infrastructure.

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6 This estimate by the Government of the Netherlands indicates that for their single country needs of silver and rare earths, which are essential for renewable energy infrastructure, are multiples of annual production alone based upon their renewable energy forecasts.

7 [https://circulareconomy.europa.eu/platform/sites/default/files/metal\\_demand\\_for\\_renewable\\_electricity\\_production\\_in\\_the\\_netherlands.pdf](https://circulareconomy.europa.eu/platform/sites/default/files/metal_demand_for_renewable_electricity_production_in_the_netherlands.pdf)

8 [https://www.asce.org/uploadedFiles/Issues\\_and\\_Advocacy/Infrastructure/Content\\_Pieces/Failure-to-Act-Energy2020-Final.pdf](https://www.asce.org/uploadedFiles/Issues_and_Advocacy/Infrastructure/Content_Pieces/Failure-to-Act-Energy2020-Final.pdf)

Source: Global Gas Flaring Tracker Report July 2020 <http://pubdocs.worldbank.org/en/503141595343850009/WB-GGFR-Report-July2020.pdf>

9 <https://www.upstreamdata.ca/>

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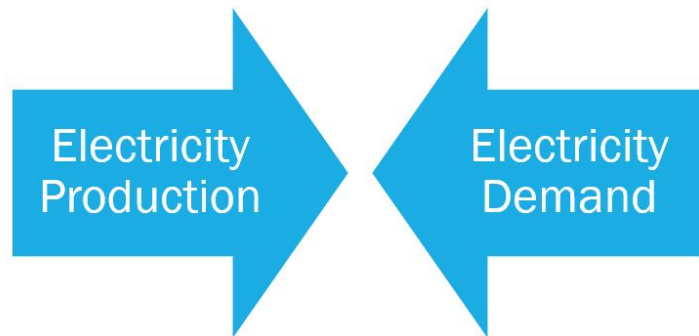
### Embedded Optionality

A traditional power plant creates value by buying fuel and selling power. The **power plant can be viewed as a strip of call options on the spread between the fuel price and the electricity price**. For gas-fired plants the spread is the “spark spread” for a coal-fired power plant it is the “dark spread”.

The consumption of electricity differs by customer type which is typically classified as industrial, professional, and household. Each customer type differs by number, consumption volume, consumption pattern, economic behaviour, needs, and the level of information known about them. Retail contracts may include a clause which gives **the retailer the right to charge the household a higher price** if they do not reduce their electricity consumption. Such a clause is an embedded put option held by the retailer.

The **Transmission System Operator (TSO)** is the entity entrusted with transporting electrical power on a national/regional basis using fixed infrastructure. **The TSO always needs optionality to maintain precise equilibrium between overall generation and consumption**. This optionality creates suboptimal outcomes given no storage for electricity, the operational constraints of major power plants, intermittency of renewable energy, and uncertain consumption patterns of customers.

### **Power Grids Must Ensure Production & Demand Equilibrium**



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However, **the Bitcoin network presents a new global customer for electricity** which is open 24/7/365 and offers a single price for electricity regardless of location or type of energy source. Viewing Bitcoin as a new electricity customer highlights the new optionality it brings to traditional energy capacity.

### **Bitcoin is a 24/7/365 Customer for Electricity**



**The Bitcoin network is a buyer of last resort for energy regardless of its geographical location bringing single pricing for energy and increasing flexibility for monetizing energy assets.**



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## **Bitcoin Mining Implications for Global Electricity Markets**

To conclude, we will summarize the implications of Bitcoin mining on the future of electricity markets and alternative energy innovation.

### **Operational Flexibility**

**Legacy power grid infrastructure is old and faces various operational challenges** which are exacerbated by the growth of decentralized alternative energy sources. In addition, the traditional capex demands imposed by connecting new energy sources with power grid infrastructure lowers the financial returns from many alternative energy projects making them uneconomic.

The **TSO requires flexibility** to ensure that electricity generation meets electricity consumption. This flexibility **manifests in various suboptimal ways** including a continued reliance on fossil fuels (as a buffer against intermittency risk of alternative energy sources), negative electricity prices, and curtailment of energy production which wastes energy.

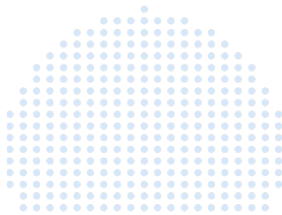
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Bitcoin mining uses mobile infrastructure which travels to the energy source thus mitigating the operational challenges of centralized power grid infrastructure. Consequently, **Bitcoin mining is responsive to any intermittency** of alternative energy sources and manages this variability much more seamlessly than a centralized power grid.

### Financial Incentives

Bitcoin mining incentive is to earn revenue in Bitcoin which is an incredibly powerful incentive and supersedes traditional energy incentives which are typically regulatory and/or subsidy driven. Bitcoin mining drives innovation to **find the lowest marginal cost energy source**– implicitly this is alternative energy rather than fossil fuels.

Furthermore, the **reduced reliance upon centralized grid infrastructure** eradicates traditional constraints on energy innovation and portends a future of localized, decentralized energy innovation by entrepreneurs seeking to find the lowest cost of energy to earn Bitcoin. This has important implications for energy sovereignty and geopolitics which go far beyond the scope of this paper, but clear **national/regional regulatory support and state-subsidized energy projects in favour of Bitcoin mining are inevitable.**



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## New Asset Class

As Bitcoin's legitimacy as an institutional-grade reserve asset grows, then so will the level of financial sophistication across the Bitcoin mining complex and the role of new institutional investors.

The Bitcoin network is the buyer of last resort for energy offering a single base-line market price and arbitraging energy regardless of its location on a 24/7/365 basis. This fundamentally changes a major challenge of traditional electricity markets which are localized and cannot be arbitrated like other commodities given the challenges around electricity storage and transportation.

Historically, Bitcoin miners have been entirely equity-financed and have absorbed all risks that stem from earning Bitcoin. Through the growth of hashrate derivatives and difficulty derivatives, new financial tools are emerging such that **the embedded risks of miners can be disaggregated, priced, and transferred to other financial actors** – like in traditional capital markets. This will bring a suite of new institutional investors who will be investing across the capital structure within Bitcoin mining leveraging their expertise in private equity, infrastructure, energy, derivatives, and structured finance. The area of MiFi will include new credit products and attract governments who see an opportunity to monetize traditionally trapped or waste energy capacity within national borders.





### Three New Global Commodities

To conclude, we will leave you with the thought of there being three new products emerging from Satoshi's white paper.

**Bitcoin:** the institutionalization of Bitcoin as a new asset class is accelerating.

**Hash Power:** hash rate is the measure of a Bitcoin miner's performance. Greater hash rate correlates with increased opportunity for receiving the block reward. In aggregate, the Bitcoin mining industry generates hash power as an output which secures the Bitcoin blockchain.

**Electricity:** The Bitcoin blockchain is the buyer of last resort for electricity. It can operate independently of legacy power infrastructure and can monetize energy from disparate sources anywhere on the globe. **This creates, for the first time, a single global market for electricity and portends a future where the unit of account for energy and electricity is in Bitcoin.**

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## Mining Finance (MiFi)

The combination of these three products is captured in Bitcoin mining. A new probabilistic fixed-income complex is emerging harnessing energy, infrastructure, electricity, and Bitcoin. It could attract capital from global institutional investors to invest across the capital structure. This is coinciding with the growing irrelevance of the traditional fixed-income asset class given the era of sustained central bank intervention and zero/negative nominal interest rates.



# Bitcoin Mining Implications for Global Electricity Markets

- Summary

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	Electricity Markets <u>without</u> Bitcoin	Electricity Markets <u>with</u> Bitcoin
<b>Operational Flexibility</b>	Old, centralized infrastructure Not built for alternative energy TSO requires optionality Energy buffering with fossil fuels	Unconstrained by legacy infrastructure Seamlessly manages energy intermittency Creates new mobile infrastructure ("Plug and Play")
<b>Financial Incentives</b>	Poor financial incentives Innovation driven by high energy prices Underutilized energy prevalent Negative electricity prices Curtailment of energy production	Incentive to earn Bitcoin Innovation driven by low energy prices Local, decentralized innovation
<b>New Asset Class</b>	Electricity cannot be stored efficiently Electricity a localized commodity Multiple electricity markets Illiquidity in electricity derivatives Poor spot/forward convergence	Global energy arbitrage Surplus electricity stored as Bitcoin A single base-line electricity market Captures embedded optionality of energy Bitcoin a new 24/7/365 buyer of energy Single, homogenous price for electricity Leverages Bitcoin's inherent fungibility New highly liquid derivatives complex New institutional investor constituencies Emergence of MiFi New credit markets BTC the unit of account for electricity

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