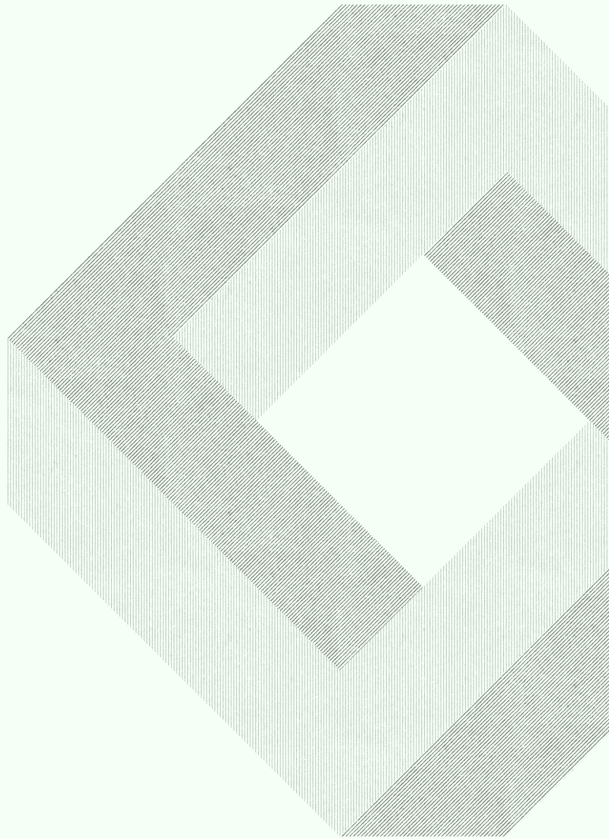
Green Mining, Stable Grids

Clarifying misconceptions about Bitcoin mining



Bitcoin Mining Stabilizes the Grid.

Bitcoin miners are driven to cheap, abundant energy. This often means energy that would go to waste, or is severely underpriced.

When there is higher demand for electricity than supply, Bitcoin miners are incentivized to curtail their operations, helping bring the grid back to equilibrium.

Further, the ability to hedge through longer term energy contracts incentivizes miners to sell energy back to the grid in times of strain.

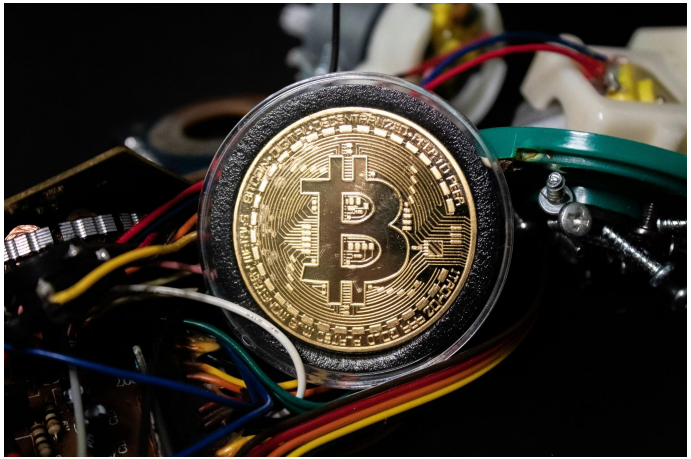
Bitcoin mining operations are also an asset to deregulated grid managers who can use them as a flexible load to balance supply and demand.

Bitcoin’s Energy Use Has Been Overblown.

One popular study claims that Bitcoin alone threatens to raise global temperatures two degrees over the next three decades, despite having been thoroughly debunked in peer reviewed journals.

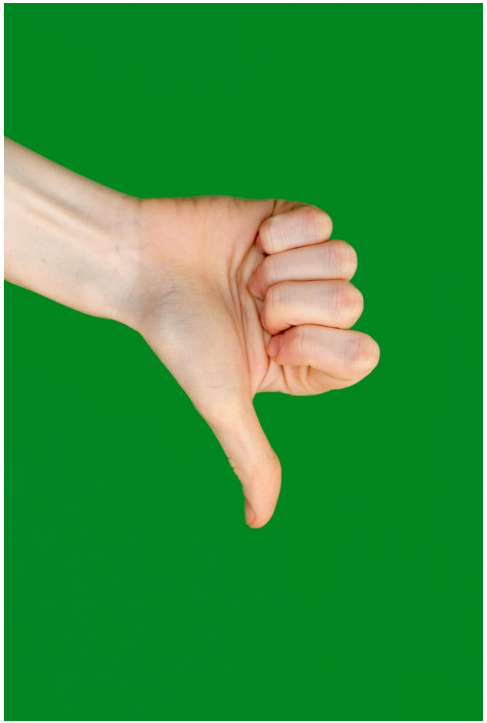
Another factually incorrect, yet broadly popularized, assessment was made by the World Economic Forum and claimed that by 2020 Bitcoin would consume more energy than the entire planet did in 2017, when it ultimately only consumed 0.046% of the world's electricity that year.

Another study that continues to be widely covered in the press stated that Bitcoin mining created as much e-waste as the IT equipment waste of the Netherlands. Yet a Cambridge study found Bitcoin's e-waste was only about 7% what had been estimated in that report.



Source: Mora et al, Dittmar and Praktiknijo, Houy, Coinshares, De Vries, Cambridge, BPI RFI Response: Climate Implications of Digital Assets, Da-Ri

These Studies Make Obvious Methodological Mistakes.



Very often studies are incorrect because they are based upon the amount of electricity used per transaction. However, emissions are not impacted by the number of transactions, but by hashing power.

Many studies also don't account for "halving," a regular process by which the reward for mining is diluted by 2. This significantly reduces the amount Bitcoin miners can pay for electricity to remain profitable.

Other common errors include underestimating the lifespan of mining technology, overestimating water usage for cooling, and the ignoring the introduction of updated data center technology.

Source: BPI RFI Response: Climate Implications of Digital Assets

In reality, Bitcoin mining uses about 0.23% of global energy at present.

It is responsible for 0.08% of the world's carbon emissions.

These percentages are set to decrease, because Bitcoin mining is increasingly renewable, and because global energy generation is increasing.

Source: BPI RFI Response: Climate Implications of Digital Assets

Yes, Bitcoin Mining is Still Energy Intensive.

The Bitcoin Network orders transactions in batches, referred to as “blocks.”

To produce a new block, a participant must guess a number between 0 and 2^{32}.

Bitcoin mining isn’t really “mining” at all — it’s using computers to guess that number, also called a “nonce.” The more numbers you are able to guess, the more likely it is you guess the correct nonce.

This decidedly more energy intensive than other consensus mechanisms.

Source: K33

But Bitcoin's Energy Use Makes it Secure.

The amount of work that goes into guessing the correct nonce is called "hashing." If someone controlled more than half of the hashing power, they could derail the network — something referred to as a 51% attack. This is the only major security risk with the Bitcoin network.

The more entities compete to guess that number, the more energy is expended. This is by design: the more "work" put in, the more secure the network is, because it makes it harder for any one entity to afford pulling off a 51% attack.

Source: K33

The Economics of Bitcoin Mining Naturally Balance the Electrical Grid.

Miners Gravitate Towards Cheap Energy

Bitcoin miners' profits are determined by the amount of Bitcoin that can be mined and the price of that Bitcoin in comparison to the price of electricity.

This means that above a certain price per unit of electricity, Bitcoin miners operate at a loss.

Source: How Bitcoin Mining's Flexibility Reduces Carbon Emissions, BPI

This Level Is Called the “Break Even Price”

The break even price varies by the miner, but those we spoke with often cited levels from $50-150 per megawatt hour (MWh).

Many Bitcoin miners have automated systems in place which evaluate electricity pricing data and shut down the majority of operations when prices rise above the strike price.

This drives Bitcoin miners towards cheap energy, and away from energy when the grid is constrained and

Because of the low strike price, the energy bitcoin miners use is often renewables or energy that would otherwise go to waste.

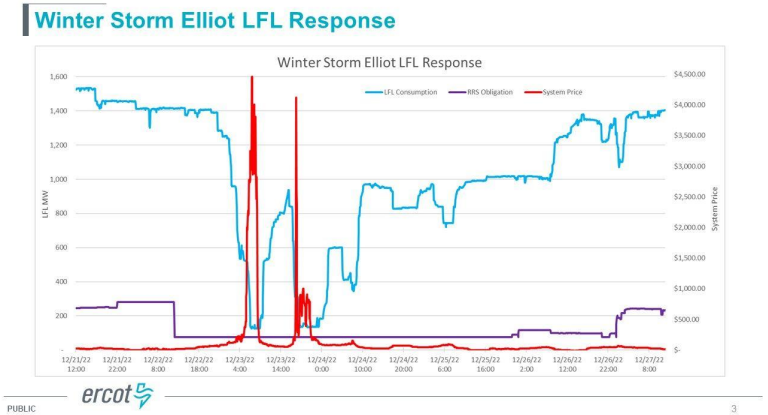
Source: How Bitcoin Mining’s Flexibility Reduces Carbon Emissions, BPI

Bitcoin Mining is a “Controllable Load”

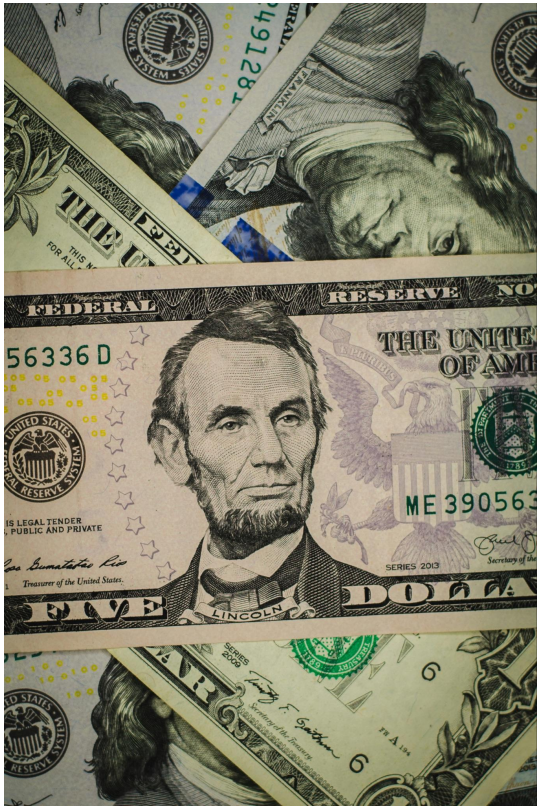
“Controllable Load” refers to the fact that Bitcoin miners can operate at any time of day.

- Bitcoin miners are able to granularly adjust their load within seconds, or turn off/on at a moment’s notice.

This is as opposed to “Non-Controllable Loads,” like AI datacenters, which must operate at the time and with the energy expenditure required to provide services to their clients.



Source: K33, ERCOT Large Flexible Load Task Force



This Makes Bitcoin Mining Price Responsive

Because Bitcoin Miners are controllable loads, they are price responsive — i.e., they tend to operate when and where electricity prices are low, and even turn off if they are unable to procure adequately inexpensive energy at a given time.

The Electric Reliability Council of Texas (ERCOT), which operates the electrical grid for most of the state, has performed several studies showing how organizations with flexible loads like Bitcoin miners turn off and on when the grid is strained, for example during Winter Storm Elliot.

Source: K33, ERCOT Large Flexible Load Task Force

Managing the Grid 101

Power grid operators like ERCOT, have the responsibility to make sure supply and demand are 100% matched.

If they are not successful, there can be brownouts or blackouts. There can also be physical repercussions, like equipment failure, or transmission wires melting.

The most commonly used tool to balance supply and demand is price: prices increase when demand increases relative to supply, and decrease when supply increases relative to demand.

Source: K33

Bitcoin Miners Are a Great Tool for Grid Stabilization

One of the best tools power grids have to stabilize the grid are bitcoin miners.

Bitcoin miners turn off/on depending on the amount the grid is being used, because this coordinates with when prices are above/below their break even price. In fact, Bitcoin miners curtail 5-31% of the time, reducing co2 emissions by 13.6 kilotons.

Source: How Bitcoin Mining's Flexibility Reduces Carbon Emissions, BPI

Cormint Shuts Down When Prices are High

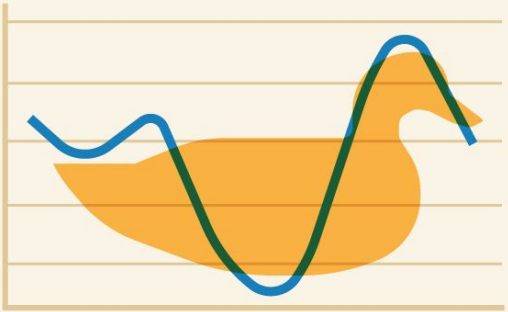
Cormint is a Bitcoin miner based in Texas that procures all their energy in the real time and day-ahead markets, just like the majority of businesses in the state.

They have an automated system which turns off 95% of their operations — everything except fans and network infrastructure — when prices rise above their break even price which is currently about $50/MWh.

Source: Cormint

Bitcoin mining makes use of renewable energy that would otherwise go to waste.

Reversing the Duck Curve



This automated system shuts off Cormint's operations once or twice per day, typically when solar power comes offline.

This means that Cormint typically stops mining at the peaks of what is called the "duck curve."

The duck curve reflects when demand for electricity increases relative to supply, and prices peak — typically in the morning as people are getting ready for work and solar power isn't yet produced at a large scale, and in the evenings when people are home from work and the sun is no longer shining.

Price-Responsiveness Counterbalances Shifting Demand

By shutting off at times when the electricity price is high, Cormint helps to stabilize the grid.

- Shutting off reduces electricity demand, reducing prices.

But operating when demand is low helps to stabilize the grid, too.

- Turning on increases electricity demand, raising prices.

By operating at times of low demand, Cormint also helps ensure that electricity generated from renewables like solar and wind, which surges during the afternoons when there's low demand, doesn't go to waste.

Bitcoin miners like Cormint thus become "price setters." The more Bitcoin miners operate, the more electricity prices level out near the break even price, indicating a more stable grid.

Source: Cormint

Surplus Energy and Grid Stabilization

Because they are driven towards cheap energy, Bitcoin miners naturally prefer to use excess energy when it's available.

This can create the economic justification for intermittent and non-controllable energy resources like wind and solar, which often generate excess electricity, to operate. Without guaranteed demand, many renewable energy resources can't obtain the investment to grow.

More diverse energy generators coming online helps maintain grid flexibility, and helps make it so a larger percentage of the grid is driven by renewables.

Source: How Bitcoin Mining's Flexibility Reduces Carbon Emissions, BPI

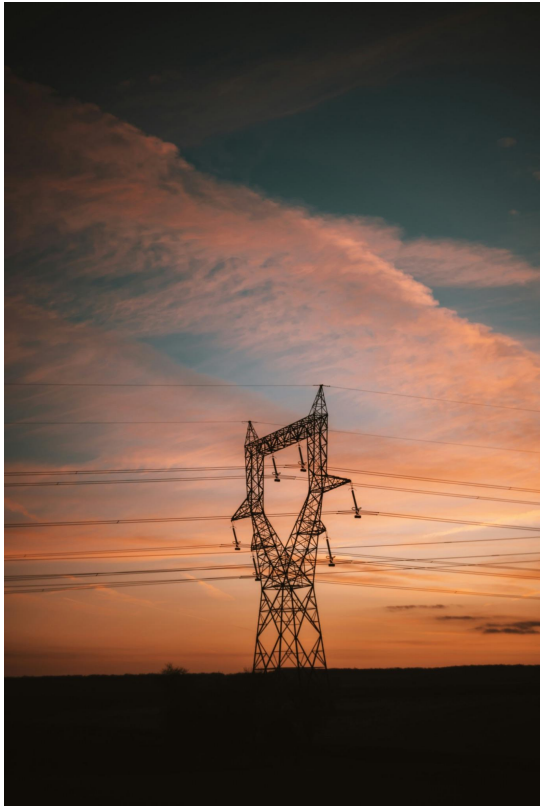
Congestion

The further the distance between the point of generation and point of consumption, the more electricity is stranded.

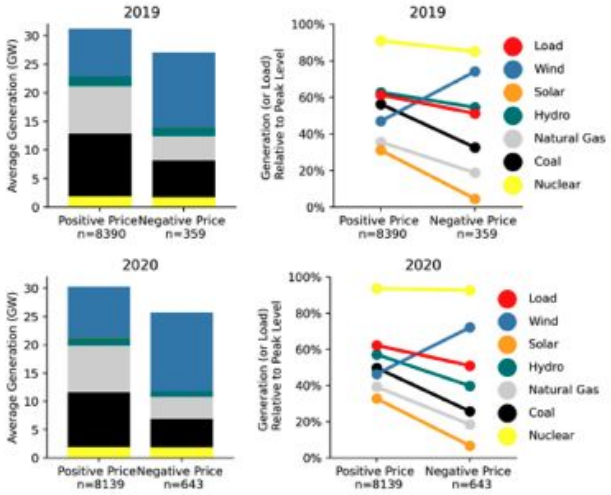
This is inconvenient, because the places where there tends to be enough land to generate renewables at significant scale — wind or solar farms, for example — tend to be remote areas far from population centers. There is often not enough load in these regions to use all the energy that is generated.

Transmitting that energy from remote areas to population centers requires expensive infrastructure, which is not built to scale in most of the country. Major transmission upgrades take years.

This results in congestion: when there isn't adequate capacity to transmit electricity from where it is generated to where it's needed.



Negative Pricing



Source: Sangha Renewables

Oftentimes, congestion results in an excess of electricity generated that goes to waste.

This is particularly common with renewables which are intermittent—i.e., it is impossible to dictate when they generate electricity, or how much electricity they generate.

- Solar, for example, can only generate electricity when the sun is shining — and the amount it generates is dependent on how sunny it is and for how long.

When a power producer makes a surplus of electricity, the grid often charges them to send it over the power lines, resulting in “negative pricing.”

Source: K33

Curtailment

Sometimes, the grid physically cannot handle the amount of electricity produced. Typically this has to do with the transmission infrastructure being put at risk should the grid accept any more energy.

In these instances, a grid operator might require an energy producer to curtail operations.

This can follow negative pricing, but not always. Sometimes prices can be positive but curtailment is required because there is a congestion issue, for example.

Matching Bitcoin Miners with Renewable Energy Plants

Sangha Renewables (“Sangha”) co-locates Bitcoin mining data centers near independent power producers whose energy would otherwise go to waste.

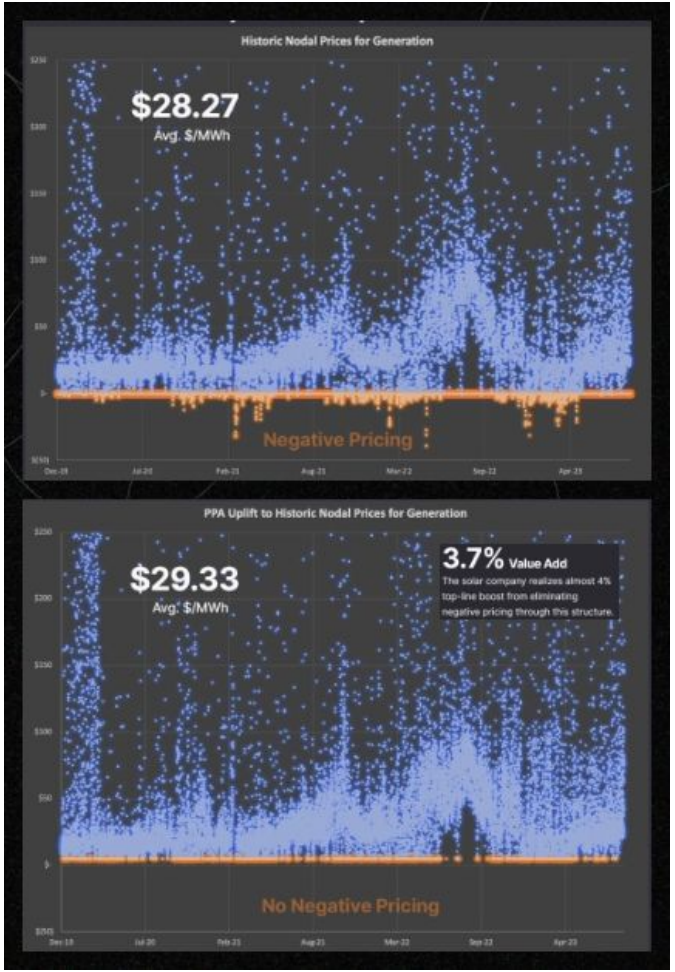
This allows Bitcoin miners to obtain competitive electricity prices (below $35/MWh).

It also helps independent renewable power producers justify their operations, by making sure that excess electricity generated at off-peak times always gets used.

Increasing Profits for Solar Companies and Bitcoin Miners

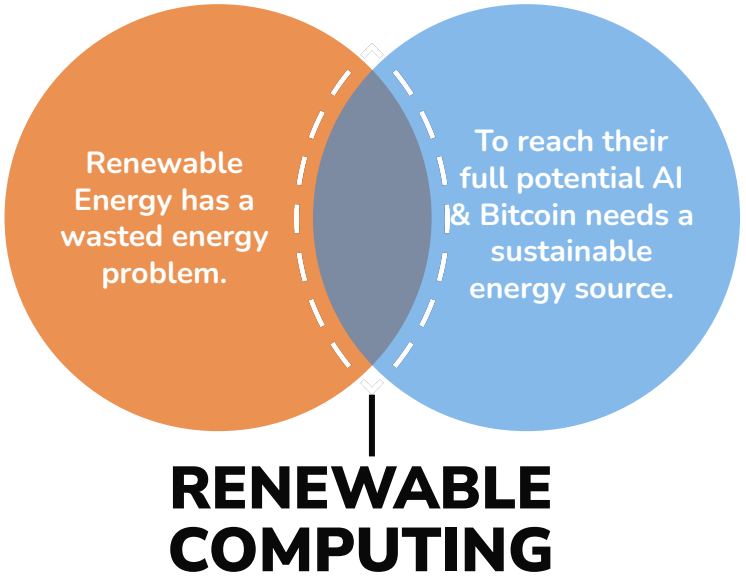
Take, for example, the Sangha Genesis Bitcoin Data Center

- Co-located with a solar generator to increase the solar generator's revenue performance, adding nearly 4% in value by eliminating negative pricing.
- Bitcoin was also mined efficiently, paying for electricity at an average of $28-$32/MWh.



Source: Sangha Renewables

Pairing Bitcoin Mining with Renewables Increases Grid Capacity



Soluna has a stated mission of bringing more renewables to the grid by pairing Bitcoin mining and AI data centers with renewable energy generation sites.

This business model doesn't just provide renewable energy producers the economic justification to operate — it also increases grid capacity for when there is increased demand by curtailing the data centers when more energy is needed.

This is because Bitcoin miners can turn off their operations when the grid is constrained, allowing the renewable energy provider with which they are paired with to direct their energy towards the general grid when extra supply is needed.

Source: Soluna Holdings

Providing Emergency Grid Stability with Renewables

Soluna's flexible Bitcoin mines consume on average 50% of energy that would otherwise be curtailed, raising significant revenues for renewable energy plants that otherwise waste about half of the energy they produce.

But that data center can also provide emergency stability to the grid in times of stress because Soluna's bitcoin mines will turn off, making that extra energy available to other users.

State government incentive programs amplify Bitcoin mining's beneficial impacts on electricity pricing and grid flexibility.

Incentivizing Grid Stabilization

But sometimes agencies don't want to wait for the markets to organically stabilize the grid.

- Not all loads are controllable, and amongst those which are, not everyone has the sophisticated technology in place to shut off precisely when the grid is constrained.
- It's also important for grid stability that there aren't immediate, large increases in demand or supply. Market forces can create large fluctuations that agencies often want to be able to temper.

In these cases, agencies will lean on economic incentives to exercise greater control over the grid.

Hedging

Some states allow companies the option to purchase electricity from their power providers in advance at a fixed rate.

This fixed rate is designed so that the company is overpaying for electricity the majority of the time in exchange for the ability to lock-in operating costs.

On the rare occasion that real-time markets are pricing electricity higher than what the company has prepaid, that company has the option to sell the prepaid electricity back into the market.

- This increases supply relative to demand, balancing the grid in times of stress.

Power Purchase Agreements Amplify Grid Stabilization

The Bitcoin mining company Riot, for example, procures some of its electricity through power purchase agreements for its mining operations in Texas.

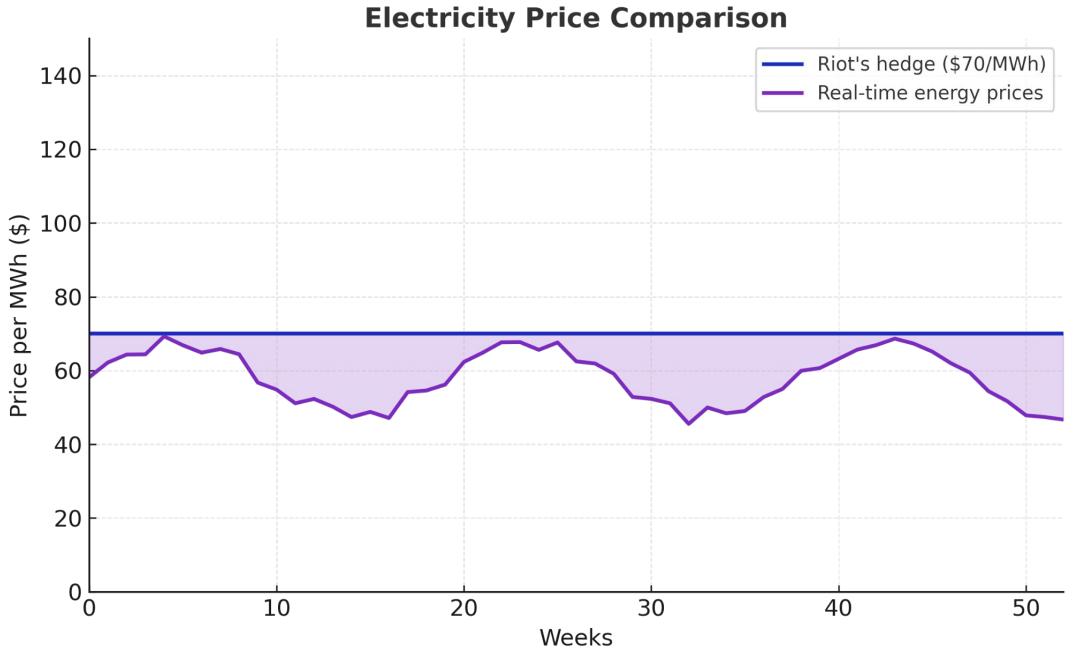
Approximately 85% of the time Riot is paying more than it would if it just bought energy at spot prices.

But when power becomes scarce, Riot has the opportunity to sell what it has pre-purchased back into the wholesale market and make back that loss.

For example, in October 2025 Riot received $2.1 million in power credits. However, credits included, they still ultimately paid about $40/MWh for electricity.

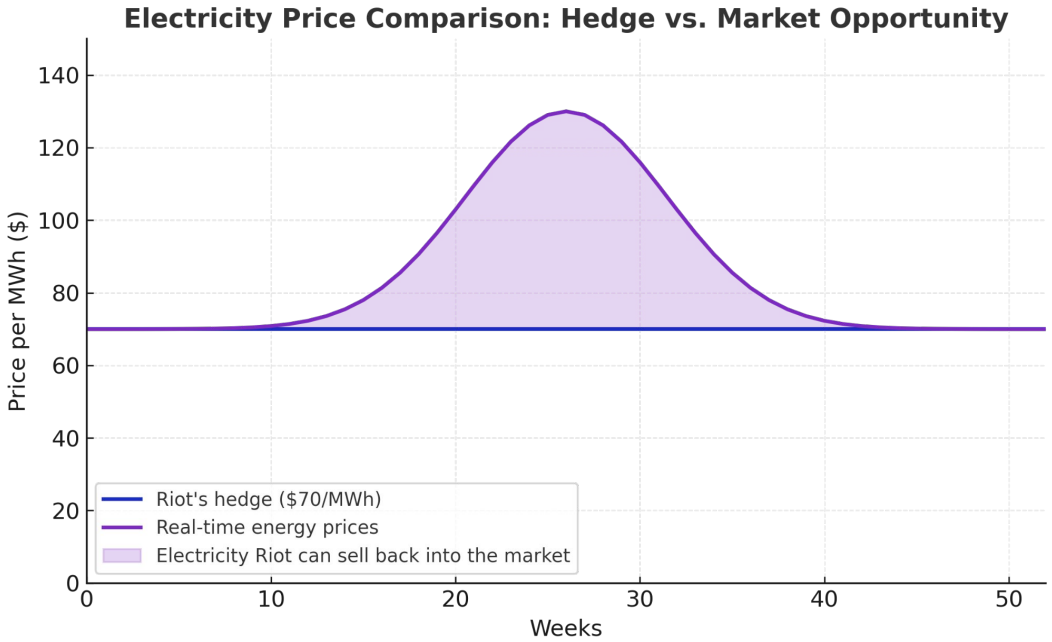
Source: Riot October 2025 Production and Operations Updates

85% of the time, prices look like this:



Note: Chart is dependent on hypothetical numbers and is not indicative of specific power purchase agreements.

15% of the time, Riot can sell electricity it pre-purchased back into the market.

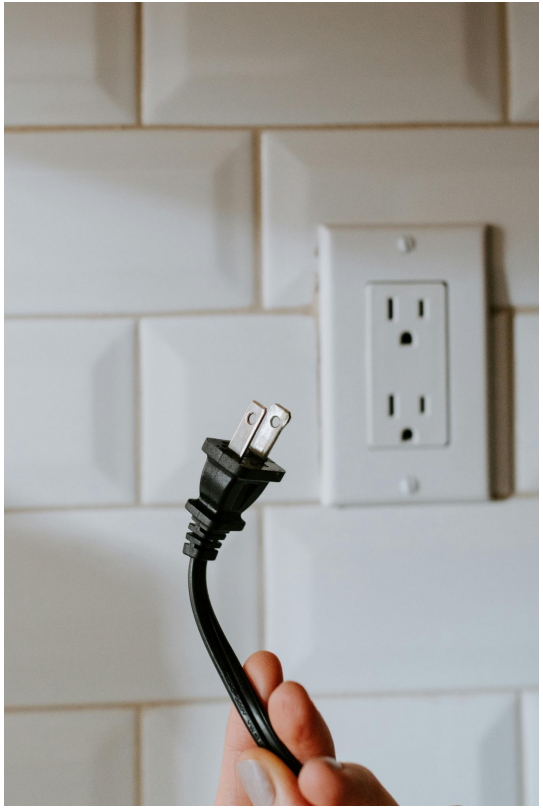


Note: Chart is dependent on hypothetical numbers and is not indicative of specific power purchase agreements.

Ancillary Services

Electrical grids also have varying ways of assuming active power control, voltage control, or frequency control in different markets.

In Texas, for example, companies can offer a bid into a statewide system. If ERCOT decides to take the bid, they will pay that company throughout the year in exchange for the power to turn their operations on or off when desired.



Ancillary Services Can Increase Energy Supply

Riot also engages in the ancillary services market, where ERCOT pays the company for the power to turn Riot's operations up or down like a dimmer switch. You can think about this as an insurance premium for ERCOT.

Most of the time, when demand outweighs supply, ERCOT actually chooses to keep Riot's operations running. This is because the grid will connect to emergency energy generation resources in times of strain that can overwhelm the system if the energy they create isn't adequately absorbed. In these cases, ERCOT actually uses Riot to absorb any excess bursts of electricity, preventing blackouts or brown outs.

However, other times ERCOT turns off Riot's operations in order to reduce demand for the grid, stabilizing electricity prices for other users.

Ancillary Services also Benefit Everyday Ratepayers

- Bitcoin miners function like batteries: Whereas batteries charge with cheap and abundant power, Bitcoin miners also mine when there is cheap and abundant power.
- When the grid needs more power to meet demand, they can turn down Bitcoin mining operations, and have the same effect as they would deploying electricity stored in batteries.
- While it might sound odd to pay companies to not operate, ancillary services end up saving ratepayers more than it costs. The price of procuring ancillary services for ratepayers in Texas dropped by 74% from 2023 to 2024, in large part because Bitcoin miners are flexible loads.

Source: Potomac Economics 2024 State of the Market Report for the ERCOT Electricity Markets

Bitcoin Mining Creates More Sustainable and Stable Grids

Bitcoin mining doesn't use as much of the grid's energy as is commonly thought.

Because they have controllable loads, Bitcoin miners naturally stabilize the grid.

Bitcoin mining economics also drive Bitcoin miners towards cheap energy, which is often renewable energy that would otherwise go to waste. Bitcoin miners' demand can help bring more renewable energy plants online, increasing electricity supply and reducing shortages.

Additional tools well-suited to Bitcoin mining, like power purchase agreements and ancillary assets programs, help local power grid operators find even more grid flexibility.

But Misconceptions Get in the Way

There is a difference between using electricity that is abundant and electricity that is scarce. Bitcoin mining uses the former, not the latter.

Electricity generated not at peak times often goes to waste

Electricity made from renewables creates less emissions
By turning off during peak times and operating during non-peak times, Bitcoin actually helps stabilize the grid, reducing brownouts and blackouts.

But instead, electricity is often portrayed as a finite resource operating on a grid with consistent demand. In this portrayal, Bitcoin miners are confused as having the same strain on the grid as technologies which require significant energy usage at all times, including when the grid is constrained.

Policy Recommendations

Bitcoin miners should not be penalized as an automatic risk to the electrical grid. Rather, the growth of Bitcoin mining should be incentivized.

Bitcoin miners who use energy that would otherwise go to waste, or who participate in state-led programs to give energy control agencies more control over the grid, should be rewarded for their good behavior.

Electricity pricing should be designed for increased flexibility.

Bitcoin miners should also be incentivized to co-locate with renewable energy providers.

Bitcoin mining should be used as a tool for stabilizing energy availability and electricity prices.

Appendix

Sources:

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