

POWER, THE ULTIMATE DRIVER OF MINING RETURNS AND RESILIENCE

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Introduction

Bitcoin mining has matured into an energy-intensive yet strategically important industry in the digital economy. At the heart of every mining operation lies a single determinant of profitability and resilience: electricity. Power represents up to 80% of operational expenditure, shaping both the cost structure of miners and the narratives surrounding their environmental impact.

This report, “Power, the Ultimate Driver of Mining Returns and Resilience”, examines Bitcoin mining through the lens of energy. It begins with the electricity consumption debate, clarifying methodologies and placing Bitcoin’s demand in a global context. From there, it explores why electricity use matters, not only as a cost driver, but as the foundation of how mining interacts with grids, regulators, and investors.

For institutional investors, power strategy is the most important variable behind hashrate returns. As electricity markets evolve, the miners who secure low-cost, flexible, and sustainable energy will capture an outsized share of Bitcoin’s future rewards.

The report also dives into the sources of power miners rely on, highlighting the unique advantages and challenges of hydro, wind, solar, nuclear, natural gas, and flare gas. Each energy type carries distinct ROI implications and risk profiles that directly affect investor outcomes.

Next, attention turns to how miners integrate with grid operations, acting as flexible, modular loads that stabilize renewable-heavy systems. Comparisons with AI and HPC data centres underscore why mining is uniquely positioned as a demand-response partner.

Finally, the report examines efficiency and heat reuse, from cutting-edge ASIC improvements to turning waste heat into an asset that supports district heating, agriculture, and industrial processes. Together, these dynamics reveal why electricity is not just a cost for miners; it is the core driver of long-term resilience and value creation.

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The Electricity Consumption Debate

Bitcoin's substantial electricity consumption remains one of the most debated aspects of the network. From academic circles to policymaking arenas, the energy footprint of proof-of-work (PoW) mining is often invoked as the defining characteristic of Bitcoin's environmental and economic profile. Critics argue that no digital asset should demand so much power when alternative consensus mechanisms, such as Proof-of-Stake (PoS), appear to offer more energy-efficient solutions. Proponents counter that Bitcoin's energy use is both necessary and productive: it secures a global monetary network without centralized control, offering resilience and neutrality that no alternative mechanism has demonstrated at scale.

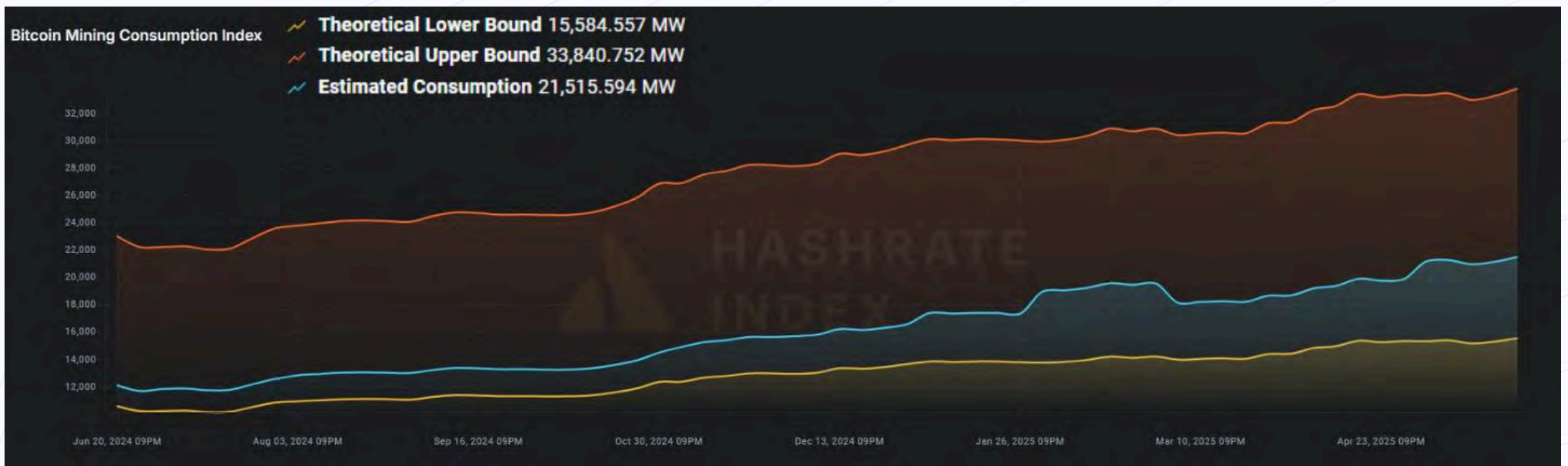
Quantifying Network Consumption

Estimating Bitcoin's energy consumption is not straightforward. Unlike traditional industries, where energy usage can be measured directly through utility data, Bitcoin mining is decentralized and globally distributed across thousands of operations. Researchers have therefore developed models to approximate consumption based on observable variables. No global registry tracks miners' energy use, so estimates rely on hashrate and assumed hardware mix, introducing uncertainty that critics often overlook.

The most common method relies on two primary inputs:

- **Network hashrate:** the aggregate computing power securing the network.
- **Hardware efficiency assumptions:** the joules per terahash (J/TH) performance of ASIC miners believed to make up the fleet.

By combining these inputs, estimates of total electricity draw can be derived. For example, the Cambridge Bitcoin Electricity Consumption Index estimates the current total power draw of the Bitcoin network at 23.19 gigawatts (GW). Hashrate Index estimates a total consumption of 21.5 GW. To put this into perspective, that is roughly comparable to the electricity consumption of countries like Australia or Poland. On a global scale, however, this figure represents only about 0.7% of worldwide electricity demand.



Bitcoin Mining Consumption Index (Source: Hashrate Index).

Criticism of Bitcoin often fixates on the absolute scale of its electricity consumption without proper context. While 21-23 GW is undeniably large, it is marginal relative to the global electricity system. The International Energy Agency (IEA) estimates total global installed capacity at 8,890 GW. Put differently, Bitcoin mining's share of global demand is a fraction of what is consumed by air conditioning worldwide, or the electricity lost annually in transmission and distribution.

Context also extends beyond raw numbers. Unlike many industrial loads, Bitcoin mining can operate in locations and with energy sources that would otherwise remain underutilized or wasted. Stranded hydro in Latin America, curtailed wind in Texas, or flared natural gas in oil fields are all examples where mining transforms wasted energy into productive value. These dynamics are central to why investors see Bitcoin mining as both a cost arbitrage opportunity and a grid asset.

Why Electricity Use Matters

The real significance of Bitcoin's electricity consumption lies in how it drives mining economics. For miners, electricity can represent 70–80% of operational expenditure. Small variations in cost per kilowatt-hour can determine whether an operation thrives or collapses. For investors, this makes power strategy the ultimate determinant of resilience and returns.

Moreover, the flexibility of Bitcoin mining distinguishes it from most other large-scale computing applications. Unlike AI or traditional data centers, which demand near-perfect uptime, Bitcoin miners can ramp power consumption up or down within minutes. This adaptability transforms mining from a perceived liability into a potential asset for electricity grids, providing demand response and stability services that are increasingly valuable in renewable-heavy systems.

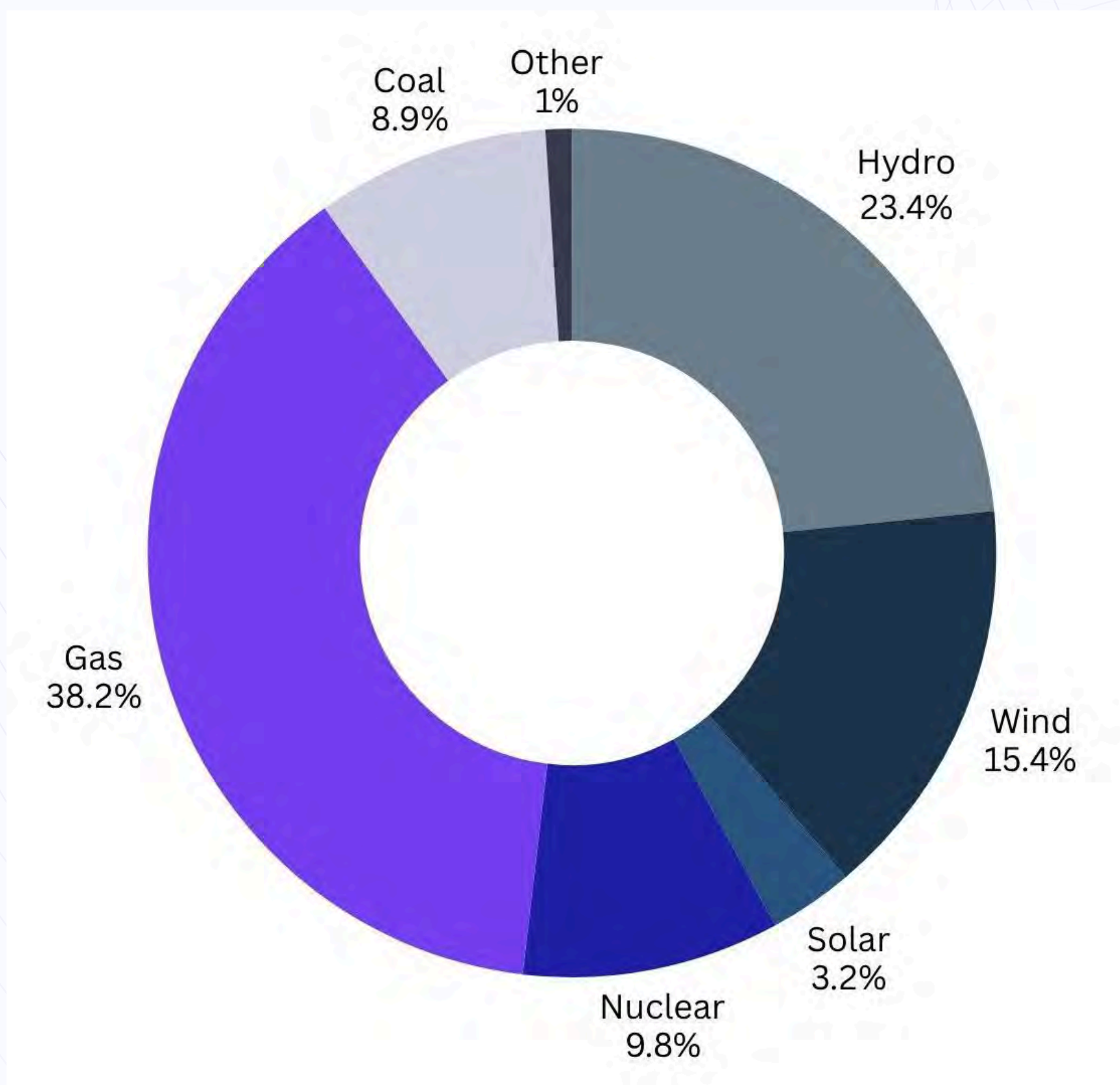
Bitcoin's electricity consumption is real and significant. But it is neither the existential threat critics suggest nor the triviality defenders sometimes claim. Understanding it requires context, accurate measurement, and an appreciation of the unique economic and technical characteristics of mining.

Sources of Energy in Bitcoin Mining

The 2025 Cambridge Digital Mining Industry Report highlights the diverse energy mix powering Bitcoin mining worldwide. Hydro remains the dominant renewable source, accounting for 23.4% of total consumption and positioning it as the single largest contributor within the sector's sustainable profile.

Overall, 52.4% of miners rely on sustainable energy sources, with renewables making up 42.6% of the mix. This includes 23.4% hydro, 15.4% wind, 3.2% solar, and 0.5% other renewables. In addition, nuclear energy represents 9.8%, underscoring its growing role as a stable, non-emitting power source.

Fossil fuels continue to represent 47.6% of total energy use, with natural gas serving as the primary driver. While reliance on fossil fuels remains significant, the steady rise of renewable and low-carbon sources reflects an industry actively diversifying its power base and reducing long-term environmental risks.



Source: Cambridge Digital Mining Industry Report

The Importance of Choosing the Right Energy Source

For Bitcoin miners, electricity is not just a cost, it is the foundation of their entire business model. The choice of power source directly shapes profitability, long-term resilience, and exposure to regulatory or market risks. For investors evaluating mining projects, understanding the underlying energy mix is therefore critical. Different energy sources carry distinct advantages and vulnerabilities, and these ripple into ROI calculations and risk management strategies.

Why Miners Love Hydropower

Hydropower has long been favoured by Bitcoin miners for its combination of stability, low cost, and abundance. Once infrastructure is built, hydroelectric generation provides a steady flow of electricity with minimal marginal costs. Locating mining facilities near hydro plants reduces transmission losses and often allows miners to negotiate advantageous rates.

From the power generator's perspective, miners help monetize excess supply that would otherwise be wasted. Seasonal flows from snowmelt or rainfall often generate surpluses that exceed grid demand. Without a buyer, this energy is curtailed. By co-locating with hydro plants, miners act as a continuous offtake partner, converting stranded electrons into value while improving grid economics. This synergy not only reduces miners' input costs but also strengthens their social license to operate, especially in regions where "use-it-or-lose-it" hydro power is regionally strategic.



Itaipu Dam - Paraguay



Renaissance Dam - Ethiopia



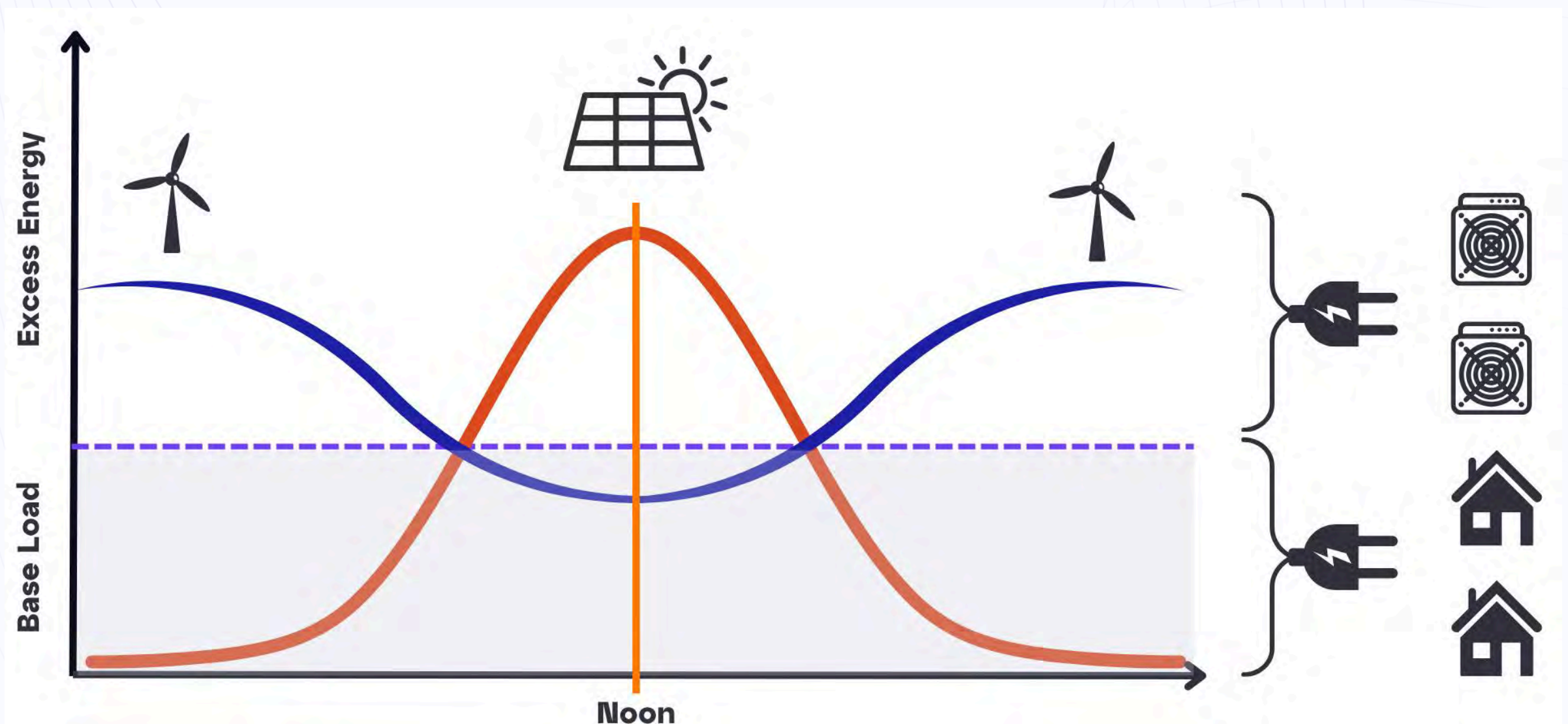
Chukha Dam - Bhutan

Key Challenges and Opportunities in Wind and Solar Integration

Wind and solar energy are also part of Bitcoin's power mix, but their integration comes with challenges that investors must weigh carefully.

1. **Intermittency:** Output depends on weather, making supply volatile and less predictable.
2. **Grid Stabilization Needs:** Intermittent generation often requires backup sources, creating inefficiencies and higher system costs.
3. **Storage Limitations:** While battery solutions are improving, they remain costly, with technical constraints on duration and reliability.
4. **Land and Location:** Solar and wind farms require vast land areas, often in remote regions, which adds transmission challenges.
5. **Low Capacity Factors:** Compared to nuclear or natural gas, wind and solar generate electricity for fewer hours of the year, reducing ROI predictability.

Bitcoin miners can provide a unique solution by purchasing excess energy from wind and solar farms when production exceeds demand. This allows miners to monetize renewable energy that would otherwise go unused, effectively transforming wasted energy into revenue. By generating income from surplus power, energy producers can recover their high initial investments more quickly. Mining revenue can also be reinvested to expand wind or solar farms or to develop energy storage solutions, such as utility-scale batteries.



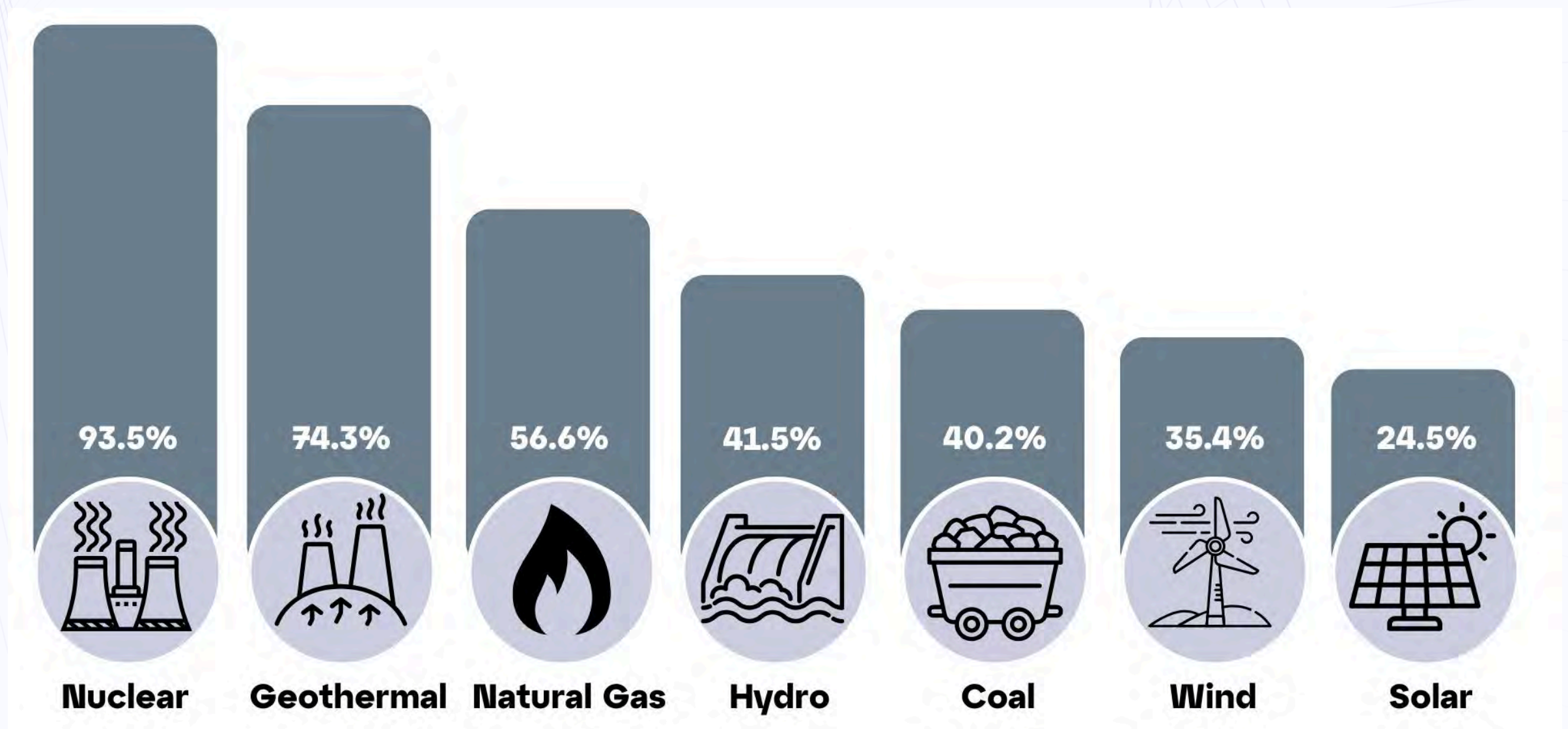
Mining Excess Energy Production Visualized (Source: Digital Mining Solutions).

Nuclear Energy's Reliability Advantage

Nuclear power offers a very different risk profile. Its chief strength lies in its high capacity factor, nuclear plants operate at near-continuous output, unaffected by weather or seasonality. For miners, this reliability translates into reduced downtime, fewer revenue interruptions, and more predictable cost structures.

Additionally, nuclear power is low-carbon, a growing consideration as miners face greater scrutiny from regulators, investors, and communities. Sourcing nuclear electricity can strengthen ESG narratives while maintaining round-the-clock uptime.

That said, there are practical limits. Very few mining operations can rely entirely on nuclear due to grid access and regulatory hurdles. Still, in markets like Texas—where nuclear makes up around 10% of generation and complements large natural gas and wind fleets—miners benefit indirectly from its stabilizing influence on the grid.



Capacity factor: actual energy produced ÷ maximum possible output if operated at full power 24/7 - indicates how reliably an energy source generates electricity over time (Source: IEA).

The Role of Natural Gas

Natural gas remains one of the dominant fuels for Bitcoin mining worldwide, particularly in North America. It appeals to miners for several reasons:

- **Abundance and Availability:** Shale production in the U.S. has created a deep and liquid market for gas. This allows miners to secure long-term contracts at competitive rates.
- **Flexibility:** Gas turbines and gensets can ramp up and down quickly, making them well-suited to provide dispatchable power in grids with high renewable penetration.
- **Stranded Gas Opportunities:** In oil fields, associated gas is often flared due to a lack of pipelines or storage. Deploying modular mining units to capture this wasted energy turns a liability into an asset.
- **Risk Considerations:** On the downside, natural gas prices are highly sensitive to geopolitics and weather. The 2021–2022 energy crisis in Europe illustrated how quickly input costs can spike. Investors evaluating gas-based mining projects must weigh the benefits of low-cost access against volatility in fuel markets.

Flared Gas Mining Opportunity

Gas flaring is the practice of burning off natural gas released during oil production, often through flare stacks at oil fields, refineries, or offshore rigs. It is done to prevent methane from venting directly into the atmosphere, as methane is over 80 times more potent as a greenhouse gas than CO₂. Yet flaring is far from clean: 10–25% of methane escapes unburned, worsening environmental impact.

Globally, flaring remains a major problem. The World Bank reported 148 billion cubic meters of gas flared in 2023, up 7% from the year before. This volume represents lost value between \$9–48 billion annually, while adding hundreds of millions of tonnes of CO₂-equivalent emissions. The U.S. ranks fourth worldwide, underscoring the scale of untapped potential in regions where much of Bitcoin mining is already concentrated.



Satellite Detected Gas Flaring (Source: SkyTruth).

Why does flaring persist? Often it is due to the absence of pipelines or infrastructure in remote areas, making it cheaper for operators to burn gas than capture it. In other cases, it acts as a safety measure during pressure build-ups. While alternatives like gas-to-liquid (GTL), compressed natural gas (CNG), or small-scale LNG plants exist, they are costly and logistically complex, limiting adoption.

Bitcoin mining offers a modular and scalable alternative. By installing generators on-site, flared gas can be converted into electricity to power ASIC miners. This

transforms an environmental liability into a monetizable asset. Mining operations are portable, adaptable to variable gas flows, and can achieve methane destruction rates of up to 98%, while reducing CO₂ emissions compared to flaring.



Flare Mitigation Project (Source: EZ Blockchain).

For oil producers, flare-gas mining provides both economic upside and regulatory compliance, helping them meet emissions standards while monetizing a wasted resource. Although critics note that reduced flaring may indirectly support more oil production, the immediate opportunity is clear: Bitcoin mining can capture stranded energy, cut emissions, and unlock billions in lost value each year.

Bitcoin Miners as Grid Balancers

Electricity grids are designed to maintain a delicate balance between supply and demand in real time. Too much generation relative to demand leads to wasted energy and infrastructure strain, while too little can cause blackouts. Balancing has traditionally been easier in fossil fuel-dominated systems, where power plants provide a stable and dispatchable supply. But as grids integrate more renewable energy sources like wind and solar, which are inherently intermittent, balancing becomes increasingly complex.

This is where Bitcoin miners have emerged as a unique and valuable asset to grid operators: they are one of the few industrial loads capable of functioning as highly flexible, instantly interruptible demand response resources.

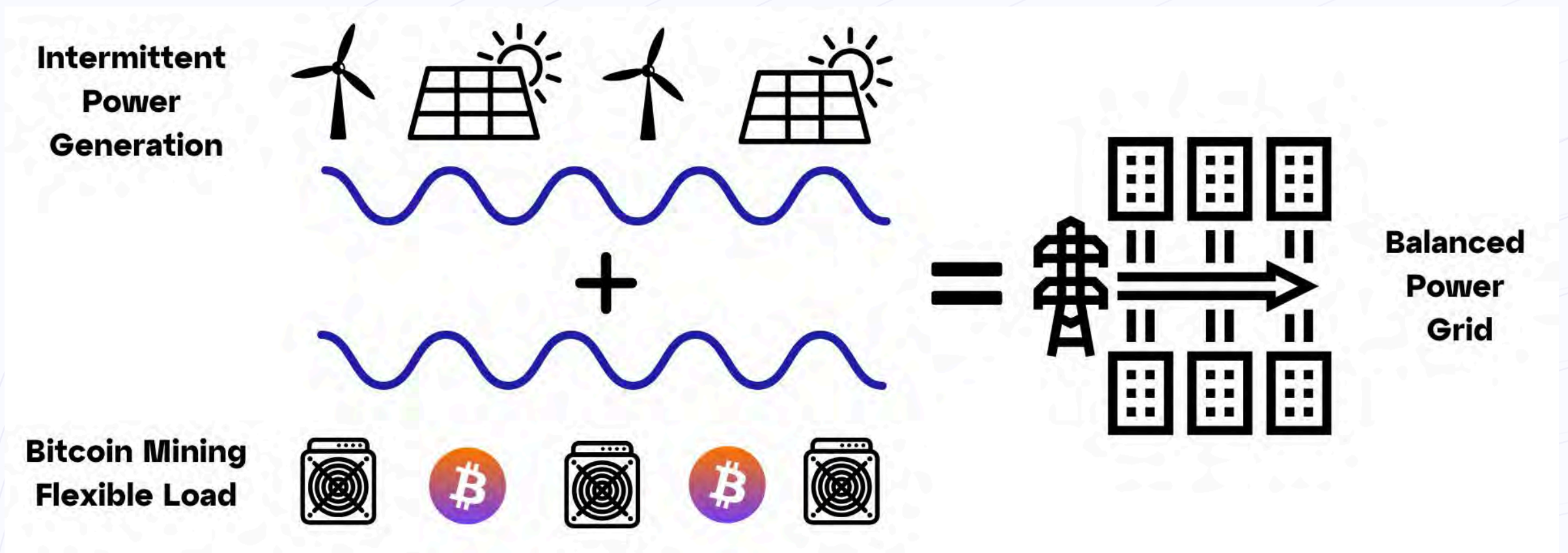
Why Bitcoin Miners Are Uniquely Suited

Bitcoin mining operations consume vast amounts of electricity but are not constrained by the same uptime requirements as data centers or industrial processes. A steel mill cannot simply turn off its furnaces without severe financial and operational consequences. By contrast, Bitcoin miners can power down their ASIC miners for minutes, hours, or even days without consequences for the Bitcoin network, damaging equipment or losing future productivity. The only trade-off is forgone block rewards during downtime.

This flexibility makes miners ideal partners for grid operators:

- Absorbing excess supply when renewable generation is high and demand is low.
- Reducing load instantly during demand spikes or supply shortages.
- Operating modularly, meaning sections of a facility can ramp down incrementally rather than going fully offline.

In effect, miners act as a shock absorber for the grid, smoothing fluctuations and making intermittent renewables more viable at scale.



Visualization of Miners Balancing the Electrical Grid (Source: Digital Mining Solutions).

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AI/HPC – A Different Kind of Load

While Bitcoin mining and AI/HPC data centers both consume large amounts of power, their relationship to the grid is fundamentally different. Bitcoin miners are uniquely flexible loads. They can curtail within seconds, absorbing excess renewable supply or shutting down during peak demand with little consequence beyond lost revenue. Uptime averages around 95%, and operations can co-locate with stranded energy like flare gas or behind-the-fence power plants. By contrast, AI/HPC data centers are firm loads with uptime requirements of 99.9% or higher. Outages can jeopardize critical workloads like medical research or financial systems. They require continuous, high-quality electricity and often install costly backup generation to ensure reliability.

Mining is modular, containers can be deployed or curtailed incrementally, making it a natural shock absorber for grids with high renewable penetration. AI/HPC facilities, however, are monolithic: clusters, cooling, and networking are tightly integrated, making curtailment impractical.

Miners enhance grid stability and can monetize wasted energy, while AI/HPC drives innovation but competes directly for premium, reliable electricity. For

investors, this means Bitcoin mining aligns with demand response and stranded energy strategies, while AI/HPC represents a continuous, high-quality power demand with higher operational rigidity.

This competition between Bitcoin miners and AI hyperscalers for megawatts is reshaping U.S. power markets, but it is not zero-sum. Mining's interruptibility complements AI's continuous demand, making both vital parts of modern grid infrastructure.

Several major digital infrastructure firms are now bridging the gap between Bitcoin mining and AI/HPC workloads, demonstrating how both can coexist and complement each other within shared energy and data frameworks. Early innovators such as Crusoe Energy and Lancium pioneered hybrid models that use excess or renewable power for both Bitcoin mining and AI computation. Building on that foundation, large-scale operators including Core Scientific, Hut 8, Iris Energy, and TeraWulf are expanding their infrastructure to host GPU-driven AI workloads alongside Bitcoin mining. This convergence highlights how flexible mining demand can help stabilize grids and monetize underutilized energy, while continuous AI/HPC workloads improve utilization and capital efficiency.

Curtailment: What It Is and Why It Matters

Curtailment refers to the temporary reduction of mining activity, usually in response to grid signals, weather conditions, or economic incentives. For miners, curtailment is not just a defensive move, it is increasingly a revenue strategy.

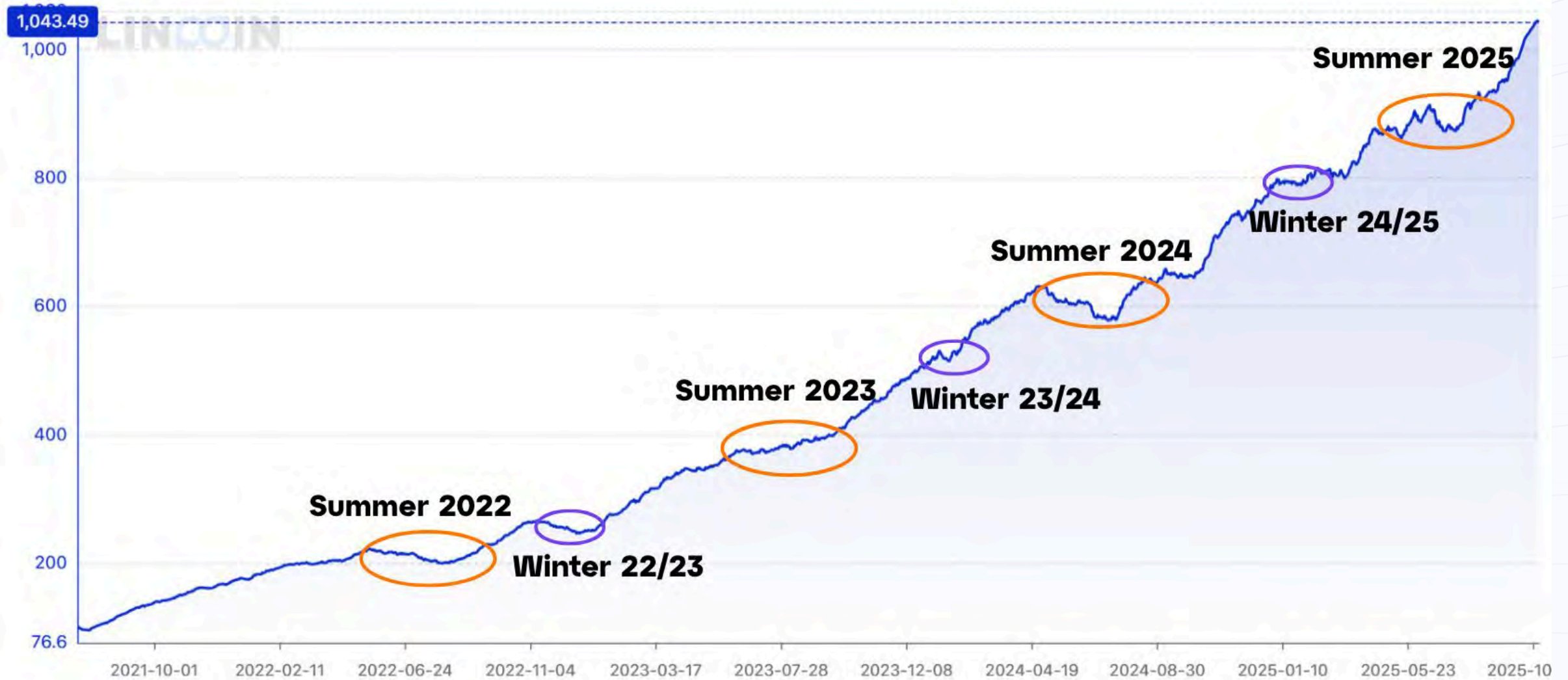
There are two main types of curtailment. The first is self-preservation curtailment whereby miners shut down to protect ASICs during extreme heat or when cooling systems are at risk of overloading. The second is so-called strategic curtailment whereby miners participate in demand response programs, turning downtime into a profit by receiving payments or credits from utilities.

This ability to convert curtailment into a financial advantage differentiates Bitcoin mining from most other industries. It aligns miner incentives with grid stability, flipping the narrative from "power-hungry operations" to grid partners.

Hashrate Seasonality and ERCOT

The effects of curtailment are visible not just on local grids but across the entire Bitcoin network. Roughly 36% of global Bitcoin mining happens in the U.S., and about half of that in Texas, under the ERCOT (Electric Reliability Council of Texas) market.

Texas is attractive for miners because of its deregulated electricity market, abundant natural gas, and rapidly growing renewable fleet. But it also experiences extreme seasonal weather, particularly scorching summers that strain the grid. During these peak periods, ERCOT frequently calls on miners to curtail. The results can be observed in the global hashrate itself, which dips in tandem with extreme weather conditions and subsequent demand surges in the U.S.



Network Hashrate Seasonality (Source: Lincoln Lens).

This “hashrate seasonality” highlights how deeply integrated miners have become with grid dynamics. When Texas miners power down in response to high demand, their actions are reflected in real-time blockchain data, creating a rare intersection between digital and physical infrastructure.

Demand Response Programs

Demand response (DR) is a structured mechanism by which large consumers, such as Bitcoin miners, adjust their energy usage to support grid stability. Participation is voluntary but financially incentivized, making it a compelling option for miners with flexible operations.

There are several types of DR programs relevant to Bitcoin miners:

1. **Incentive-based DR:** Utilities pay miners to reduce load during predetermined times.
2. **Price-based DR:** Miners respond to wholesale price signals, shutting down when electricity prices spike and restarting when prices normalize.
3. **Emergency DR:** In crisis conditions, miners must immediately curtail to keep

the grid from failing.

Because miners can respond within seconds, they outperform most industrial loads in these programs, maximizing both their financial returns and their contribution to grid reliability.

4CP in ERCOT: Turning Risk into Opportunity

One of the most influential mechanisms in ERCOT is the Four Coincident Peaks (4CP) rule. Each summer, ERCOT identifies the four 15-minute intervals—one in each of June, July, August, and September—when total system demand reaches its maximum. A company's power consumption during these intervals determines its transmission charges for the entire following year.

For miners, this can mean the difference between profitability and loss. Operating at full throttle during 4CP windows locks in massive annual transmission costs. Savvy operators, however, monitor grid conditions closely, using software to predict when 4CP events are likely and automating load drops accordingly.

By curtailing during those critical 15-minute intervals, miners not only avoid steep costs but also provide ERCOT with desperately needed flexibility. This makes them both cheaper to operate and more valuable to the grid.

Natural Gas, Renewables, and Grid Integration

Grid balancing is also influenced by the energy sources miners rely on. Natural gas-powered sites can ramp up or down quickly, complementing renewable integration. Hydro-based miners absorb seasonal surpluses, while those connected to wind and solar farms provide an immediate sink for otherwise curtailed energy. This adaptability makes miners key players in the transition to cleaner, more variable power systems.

Bitcoin miners are not just energy consumers; they are increasingly grid stabilizers. Their ability to rapidly curtail or absorb power makes them uniquely valuable in renewable-heavy systems. For investors, this flexibility translates into stronger ROI, lower risk, and a narrative that reframes mining as part of the solution to modern grid challenges.

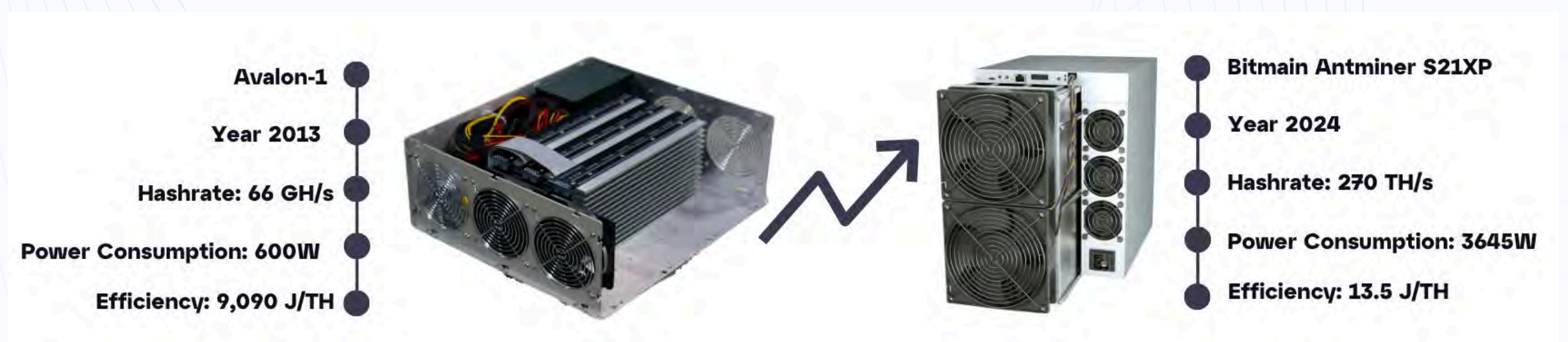
Efficiency in Bitcoin Mining: Hardware and Operations

The story of Bitcoin mining over the past several years has been one of rapid technological advancement combined with a maturing digital mining landscape. Together, these forces have driven substantial gains in efficiency, reshaping the relationship between network growth and electricity consumption.

Efficiency in Bitcoin mining refers to the amount of energy required to perform a unit of computational work, expressed in joules per terahash (J/TH). It's the metric investors watch most closely, as lower joules per terahash directly improve margins and capital efficiency. Lower values mean less energy is needed for the same output, making efficiency one of the most important metrics for assessing mining hardware performance and profitability.

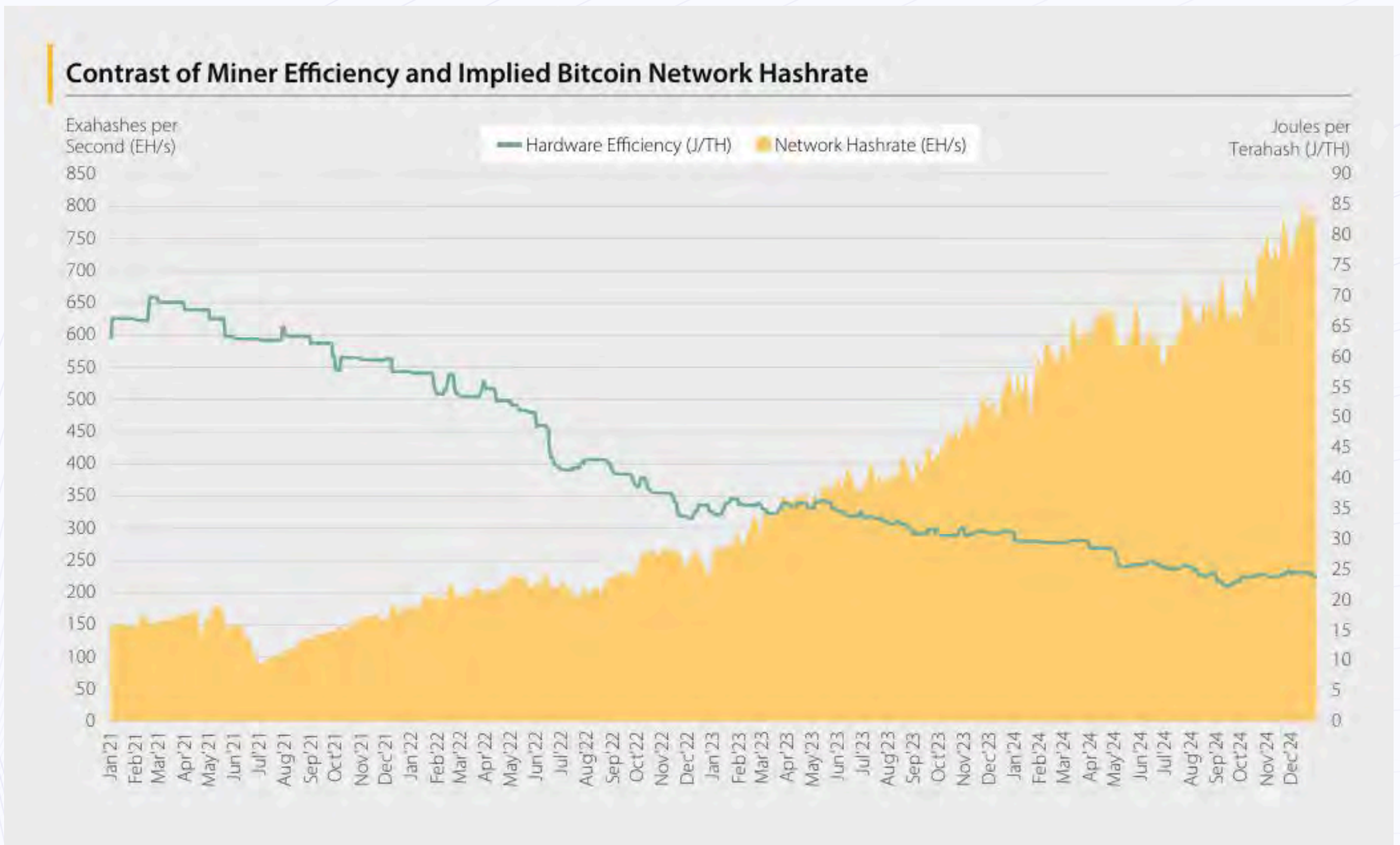
Evolution of Efficiency

In Bitcoin's early days, miners relied on CPUs and later GPUs, with limited efficiency. The first ASIC miner, the Avalon-1 released in 2013, achieved just 0.066 TH/s while consuming 600 watts, an efficiency of 9,090 J/TH. By contrast, modern miners such as Bitmain's Antminer S21XP deliver 270 TH/s at 3,645 watts, or 13.5 J/TH. In just over a decade, hashrate output has increased more than 4,000%, while energy efficiency has improved by nearly 99%.



The Evolution of ASIC Hardware Efficiency (Source: Canaan & Bitmain).

This evolution is also visible at the network level. Between January 2021 and December 2024, weighted fleet efficiency, according to a study by the Cambridge Centre for Alternative Finance (CCAF), improved from around 60 J/TH to 23.7 J/TH. Over the same period, implied hashrate surged 455%, from 143 EH/s to 796 EH/s. Electricity consumption rose more moderately, from 7.6 GW to 24.5 GW by late 2024, a 222% increase. In other words, while the network's computing power grew exponentially, efficiency gains helped keep electricity use in check.



Hardware Efficiency vs Network Hashrate (source: CCAF).

Slowing Pace of Efficiency Improvements

In the early years, each new ASIC generation delivered 5–10x leaps in efficiency. Today, improvements are incremental. Current flagship devices operate at 12–15 J/TH, and new models coming to market early 2026 are expected to reach sub-10 J/TH. Yet these advances are harder won, reflecting the physical limits of semiconductor scaling.

Modern ASICs are built on 3nm process nodes, compared to 55nm in early designs. Shrinking chips packs more transistors into the same space but introduces new problems: higher heat density, lower defect tolerance, and greater sensitivity to voltage fluctuations and quantum effects. These challenges make further efficiency improvements more costly and complex.

The Growing Role of PUE

While chip-level innovation has been the main driver of efficiency improvements, the sector is now confronting diminishing returns. Marginal improvements in joules per terahash are still possible, but operational efficiency is becoming just as important to sustaining profitability.

Historically, miners focused on electricity price and hardware performance. But in the post-2024 halving landscape, where miner revenues have been compressed, every watt of overhead matters. In the world of data centers, Power Usage Effectiveness (PUE) is one of the most commonly cited metrics for energy efficiency. Nowadays PUE isn't just a concern for traditional enterprise or cloud data centers, it's becoming increasingly relevant in Bitcoin mining as well.

Five Key Factors Driving PUE

1. **Cooling Systems:** ASICs generate substantial heat, and cooling can consume a large share of total facility energy.
2. **Climate:** Colder regions allow for free cooling, while hot, humid climates demand more mechanical intervention.
3. **Power Distribution:** Losses from transformers and conversions add to overhead unless carefully managed.
4. **Facility Design:** Airflow management, hot/cold aisle containment, and modular builds all reduce cooling demand.
5. **IT Load Utilization:** Underutilized facilities still consume baseline power, worsening PUE. Maximizing ASIC miner use is critical.

Efficiency in Bitcoin mining is a dual story. Hardware innovation has slashed joules per terahash, allowing enormous hashrate growth without proportional increases in electricity use. But as chip-level improvements plateau, operational efficiency through PUE and infrastructure design is becoming the frontier of competitive advantage. For miners and investors alike, both dimensions now define resilience and returns.

Optimizing Cost by Turning Heat Byproduct into an Asset

Massive Potential in Heat Recovery

Nearly 90% of all the electricity miners consume is converted into heat. For most of the industry's history, this heat has been treated as waste, requiring significant effort and expense to cool machines and keep operations running. But in colder climates and in industries that require steady heat inputs, this “waste” can be transformed into a valuable resource.

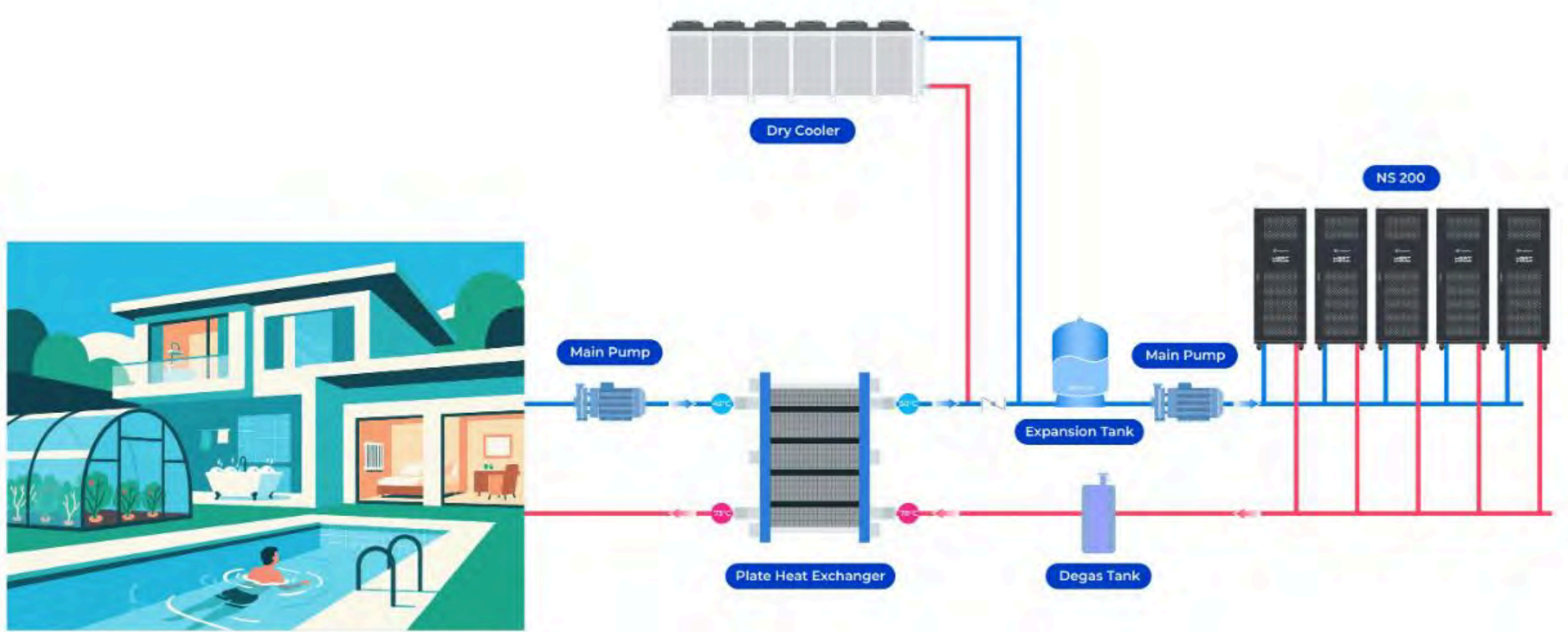
Finland provides a leading example. With one of the world's most advanced district heating networks, the country has created a natural synergy between high-heat-output industries and municipal heating. Here, the outlet temperature of mining operations matches the requirements of local heating systems. Through heat exchangers, mining facilities can deliver up to 90% of their consumed energy back as usable heat.

How Heat Reuse Works

Bitcoin miners generate low- to mid-grade heat, typically between 40°C and 80°C. Repurposing this heat requires capturing it and redirecting it to productive uses:

- **Air-cooling:** Redirects warm air from ASICs into nearby buildings.
- **Immersion cooling:** Miners are submerged in dielectric fluid, which absorbs heat efficiently and transfers it via heat exchangers.
- **Hydro cooling:** Water circulates through ASIC cooling plates, removing heat directly into water loops connected to heating systems.

Liquid-based systems are particularly effective because they allow precise temperature control and higher heat recovery efficiency. Modular mining containers can be placed directly next to facilities needing heat, enabling scalability and portability.



Bitcoin Mining Boiler to Reuse Heat (source: HeatCore).

Why Repurpose Waste Heat?

Electricity accounts for up to 80% of mining OPEX. By reusing heat, miners extract value from the same unit of energy twice. Selling heat or offsetting local heating costs creates a secondary revenue stream, shortening ROI timelines and boosting margins.

Industries that depend on heat like greenhouses and aquaculture, have been hit hard by fluctuations in natural gas. By integrating with Bitcoin mining, these industries can generate both heat and digital assets simultaneously, reducing dependence on volatile fossil fuels.

Heating systems are the largest single source of global CO₂ emissions, often powered by coal, propane, or bunker fuel. Repurposing mining heat reduces emissions by replacing these fuels with recycled energy, especially when miners themselves operate on renewable power.

Waste heat applied to agriculture can enable year-round local food production in colder climates. Heated greenhouses produce fresh vegetables closer to consumers, reducing food imports, waste, and costs. In regions like Northern Europe or Canada, this could improve both nutrition security and local resilience.

Applications for Repurposed Heat

There are multiple use cases for repurposing heat produced by Bitcoin mining. In countries with cold climates, such as Finland, Canada, and Sweden, district heating is widespread. Mining heat can supplement or replace fossil fuels in these networks. This reduces municipal costs and enhances ESG alignment.

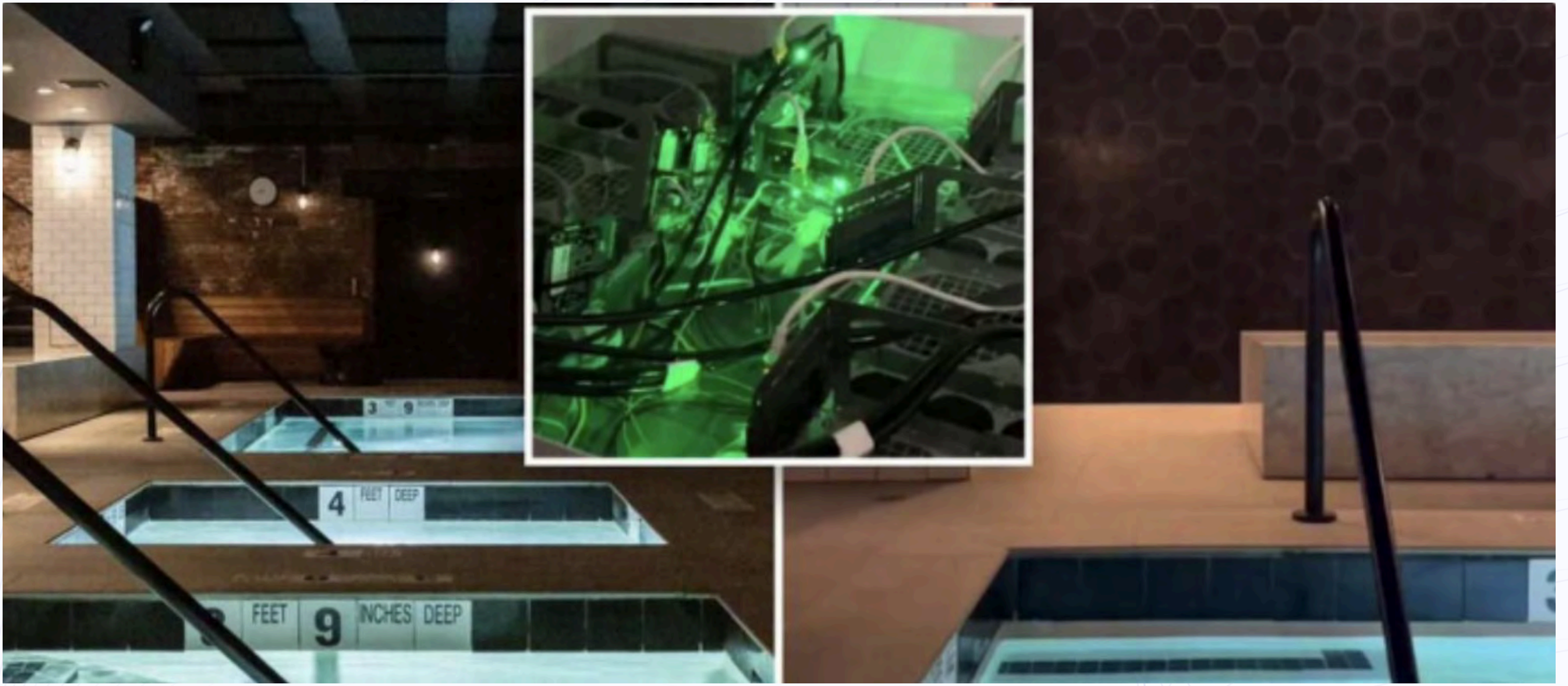
Bitcoin mining heat can create ideal conditions for greenhouses, enabling farmers to grow crops year-round. Companies in Canada, the Netherlands and Scandinavia have experimented with vertical farming powered by mining heat, producing local vegetables with lower transport emissions.



Sustainable heating solutions for growers (Source: GreenTech.Technologies)

Fish farming requires carefully controlled water temperatures. Mining heat provides a stable, low-cost source of thermal energy to maintain tanks, an ideal application in aquaculture. Also food processing industries like drying, fermentation, and distillation require constant moderate heat. Mining heat can preheat water or air, offsetting part of these processes' energy requirements.

There are also creative initiatives where Bitcoin mining set-ups have been connected to spas, swimming pools, and saunas. Since rigs produce steady, predictable heat, they are well-suited for maintaining consistent water or air temperatures in leisure facilities.



Brooklyn Bathhouse Heated by Bitcoin Miners (source: NY Times).

Heat as Critical Infrastructure

When Bitcoin mining facilities tie into essential systems like heating networks or grid balancing, they transition from optional industrial loads into critical infrastructure. Shutting them down suddenly would mean cutting off heat to neighbourhoods or destabilizing the grid.

This integration significantly lowers operational and regulatory risks. Local governments are more inclined to permit, support, and even subsidize projects that contribute to heating, emissions reductions, or food security. In some jurisdictions, being classified as critical infrastructure can streamline permits, lock in long-term site access, and even provide legal protections during energy crises. For investors, this means greater resilience and stability.

Plug-and-Play Home Solutions

Repurposed heat from Bitcoin mining can be utilized across a wide range of applications, from large-scale industrial systems to smaller residential setups. This adaptability makes heat recovery an appealing opportunity not only for massive mining farms but also for individual home-based miners. Interestingly, much of the innovation in heat reuse has been driven by DIY enthusiasts experimenting with creative ways to integrate mining hardware into their heating systems. In the past, home miners often had to rely on custom-built setups and hands-on engineering to make heat recovery feasible. Today, however, the landscape has evolved significantly, ready-made solutions like Bitcoin mining space heaters are now commercially available, offering a plug-and-play experience for everyday users.



Home Heating Solution by Canaan (Source: Canaan).

Heat as a Path to Resilience

Heat reuse is one of the most promising frontiers for Bitcoin mining. Instead of treating heat as a costly waste stream, miners can transform it into economic value, public infrastructure, and climate solutions. From district heating in Finland to greenhouse farming in Canada, the potential is vast and largely untapped.

Bitcoin mining, long painted as an energy-intensive burden, may well prove to be an engine of efficiency, where every electron does double duty, securing the world's most resilient monetary network while heating homes, feeding communities, and powering industries.

From Energy Consumer to Infrastructure Investment

For more than a decade, the conversation around Bitcoin mining has been dominated by its electricity use. Headlines often cast miners as energy-hungry industries competing with households and businesses for scarce resources. But as this report has shown, such a narrow framing overlooks the strategic role miners play in modern energy systems and the value they can unlock when integrated into critical infrastructure.

Mining is no longer just about converting cheap electricity into Bitcoin. It is about absorbing stranded and wasted energy, monetizing flare gas, providing demand-response services, and stabilizing renewable-heavy grids. It is about repurposing waste heat to warm homes, power greenhouses, or support industrial processes. In regions like Finland, Texas, and Alberta, miners are increasingly embedded into essential systems, providing public and economic value.

For investors, this marks a fundamental shift. Mining should not be assessed solely as an energy consumer with volatile margins, but as an infrastructure investment that generates both financial returns and system-wide benefits. By aligning with grid operators, municipalities, and energy producers, miners position themselves as long-term contributors to energy resilience, carbon reduction, and technological progress.

The future of Bitcoin mining will be defined not by the terawatts it consumes but by the infrastructure it supports. Mining is more than a speculative enterprise, it is becoming a cornerstone of the digital and energy economies of the 21st century.

GoMining Institutional

GoMining Institutional delivers structured Bitcoin mining and yield solutions for eligible investors, including institutions, family offices, and HNWIs.

As the institutional arm of GoMining, we provide access to professionally managed mining infrastructure and strategic exposure to Bitcoin's economic backbone.

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- Research-driven market updates and thought leadership

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About the Authors and GoMining Institutional

Nico Smid — Research Analyst, GoMining Institutional

Nico Smid, founder of Digital Mining Solutions, brings over 15 years of international business experience to the Bitcoin mining industry. Since entering the digital asset space in 2017, he has evolved from a private investor to an active miner and strategic advisor, building expertise across the full mining value chain.

Recognized as a trusted advisor and skilled industry connector, Nico has helped numerous companies launch, scale, and optimize Bitcoin mining operations across diverse geographies. Through Digital Mining Solutions, he has delivered a comprehensive suite of services—including market intelligence, strategic advisory, investor readiness, and deal facilitation—empowering clients to make informed decisions, attract institutional capital, and stay competitive.

Nico brings this experience to his role as Research Analyst at GoMining Institutional, where he focuses on delivering high-quality insights, industry analysis, and data-driven research for investors and stakeholders seeking exposure to the Bitcoin mining sector.

Fakhul Miah — Managing Director, GoMining Institutional

Fakhul Miah leads the institutional business at GoMining, where he is responsible for delivering structured Bitcoin mining products tailored to institutional investors, family offices, and high-net-worth individuals. He brings over 20 years of experience across traditional finance and blockchain innovation, with a focus on risk, infrastructure, and compliant product development.

Previously, Fakhul served as Global Head of Margin Financing and Risk Operations at Morgan Stanley, where he led a global 50-person team overseeing risk exposure, margin lending, and collateral operations for Prime Brokerage and Wealth Management clients. He managed cross-border teams across the U.S., Europe, and Asia, and played a key role in delivering large-scale regulatory, risk, and product initiatives, including the rollout of CME Bitcoin Futures in 2017.

He has since held executive roles at Web3 pioneers including CreDA and Elastos, building solutions at the intersection of decentralized identity, DeFi, and DAO governance. At GoMining, his focus is on bridging institutional capital with Bitcoin mining infrastructure through professionally managed, regulatory-aligned offerings.

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