Unlocking Abundance in the Age of Bitcoin:

A New Architecture for Energy & Finance

MARA

Introduction

At the Future Investment Initiative (FII) 9th edition 2025, global leaders will gather to address the paradoxes that define this era: the *Paradox of Progress*, the *Paradox of Innovation,* and the *Paradox of Fragmentation* — where growth produces waste, technological advancement strains resources, and globalization weakens cooperation. These paradoxes highlight a central reality: abundance by itself is not enough. Without effective mechanisms to channel it, abundance can lead to inefficiency, instability, and division.

The Paradox of Progress: Globally, more electricity is generated than ever, driving economic growth. Yet much of this abundance is underutilized. Without adequate infrastructure, as much as 2,000 TWh of renewable output could be lost to curtailment and connection delays by 2030,[1] almost half of the electricity consumed in the U.S. in 2024.[2] Similarly, over 150 billion cubic meters of natural gas was flared in 2024, [3] comparable to the annual emissions of 91 million gas-powered cars.[4] Excess energy surrounds us, but without tools, markets, and infrastructure to capture it, progress paradoxically leads to waste.

The Paradox of Innovation: Advancements in AI are already impacting productivity. A recent survey showed that 67% of respondents saved two or more hours of work per week by leveraging generative AI.[5] Yet these boosts in productivity do not come without a cost. AI data centers create rigid and rapidly growing demands for fiber, water, and energy. McKinsey projects that AI data center power demand could grow by three and a half times by 2030.[6] As this strain on the grid grows, so too does the need for technologies that absorb inefficiencies within existing infrastructure.

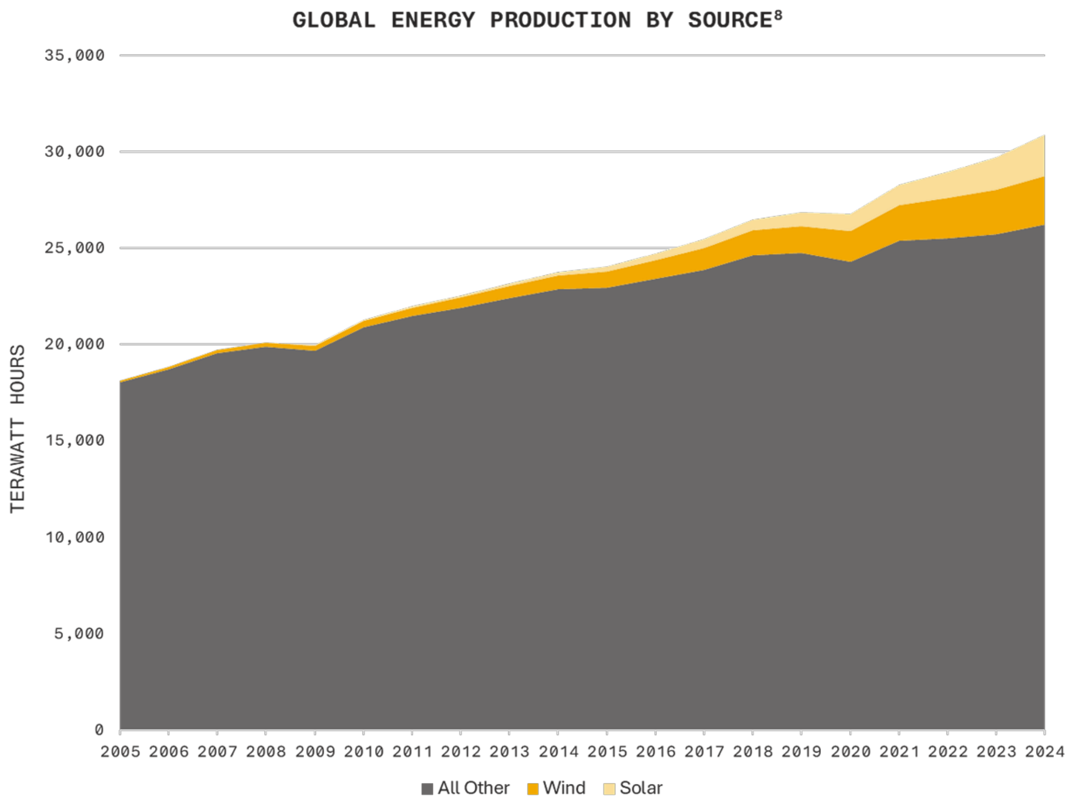
The Paradox of Fragmentation: For decades, globalization has bound economies closer together, facilitating unprecedented economic growth, trade, and opportunity. Yet today, increased geopolitical tension has fractured commerce and constrained access to capital. Nearly one-third of all nations now live under sanctions, underscoring how factors that once enabled global integration are now driving fragmentation.[7] To prevent further fragmentation, markets may increasingly look to assets like bitcoin for secure financial infrastructure.

Across energy, technology, and finance, these paradoxes converge on a single theme: abundance is not sufficient on its own. Increased electricity production creates excess energy when it cannot reach markets. Technological advancements intensify demand for resources. And without open financial infrastructure, abundance risks dividing economies instead of uniting them.

Bitcoin mining offers one potential path forward. It can turn excess energy into value, create stability with increased adoption, and provide decentralized financial infrastructure for a resilient asset. This report examines how Bitcoin mining is applied in practice, from North American wind farms and oilfields to Finnish communities and Emirati energy projects. By turning excess energy into digital capital, volatility into resilience, and fragmentation into inclusion, Bitcoin mining illustrates how today's paradoxes can be reframed as opportunities.

The Paradox of Progress: Building Prosperity from Excess Energy

Energy abundance has raised living standards for global populations, but aging grids and limited transmission capacity prevent much of it from reaching consumers. These infrastructure bottlenecks result in energy curtailment, leaving valuable assets to sit idle when they could be generating electricity.



SOURCE: OUR WORLD IN DATA

The curtailment challenge is most acute for clean energy. Variable renewable energy sources like wind and solar have seen unprecedented adoption, a vital step for decarbonization. Between 2018 and 2023, their installed capacity more than doubled, and their share of global electricity generation nearly doubled.[9] Many countries have pledged to triple global renewable capacity by 2030, suggesting this growth will only accelerate.[10]

However, without parallel investment in infrastructure, as much as 15% of variable renewable energy output could be lost to curtailment and connection delays by 2030.[11] That amounts to about 2,000 TWh of clean energy,[12] approximately 50% of U.S. total energy consumption in 2024.[13] Today, curtailment for wind and solar already averages around 3% of generation.[14] And in markets with high renewable penetration like California, historical data estimates that only 91% of the output from new solar capacity adds to the renewable supply, with the remaining 9% lost to curtailment.[15]

Bitcoin mining provides a scalable way to monetize this excess energy by bringing demand directly to the source. Unlike many conventional loads, mining facilities can easily collocate alongside generation, avoiding the bottlenecks of transmission and creating an immediate outlet for electricity that would otherwise be curtailed. Their modular design allows new load to be deployed quickly and at scale, ensuring that every additional megawatt of renewable capacity has a path to market. By converting excess production into revenue, mining strengthens project economics and could give developers greater confidence to expand renewable investments.

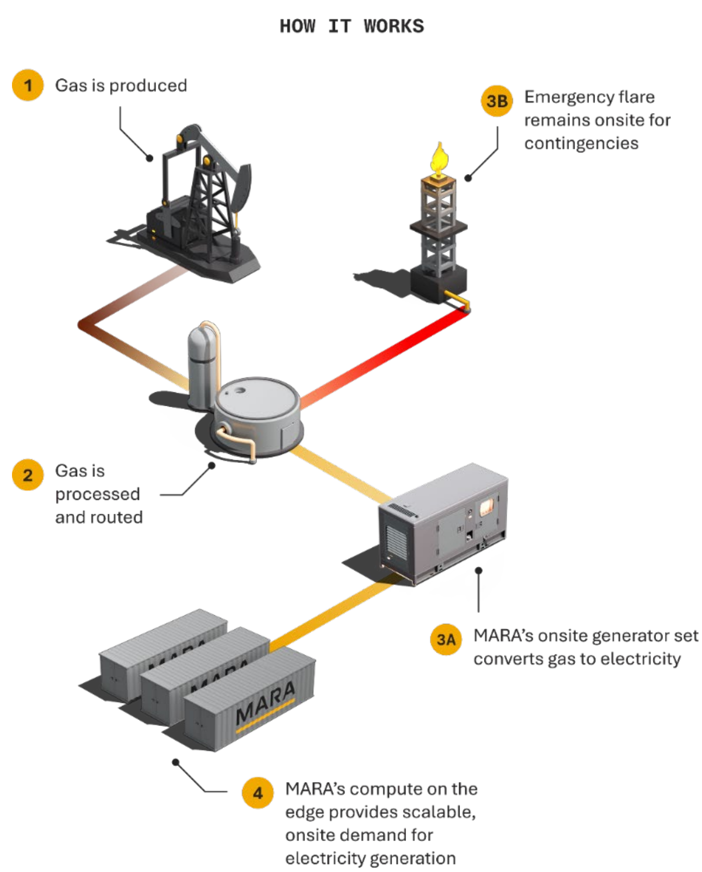
According to recent peer-reviewed research, establishing Bitcoin mining alongside a solar farm in the UAE could cut the project's payback period by more than half, shortening it from over eight years to about three and a half years.[16] Moreover, the findings suggest that by implementing such a system, energy officials could design more attractive proposals to encourage investment, further boosting renewable project economics and accelerating the expansion of clean energy infrastructure.

Photo of MARA's wind farm and on-site data center in Hansford County, Texas.

MARA has applied this model across continents. At MARA's 76-turbine wind farm in Texas, the company recently completed construction of an on-site Bitcoin mining data center designed to capture otherwise curtailed energy during periods of grid congestion. In the UAE, MARA's sites help monetize excess energy created by seasonal fluctuations in demand, supporting grid stability and ensuring more efficient use of available capacity. Bitcoin mining enables energy producers to monetize excess supply, improving utilization and reducing the need for curtailment.

Stranded energy is also a significant challenge in the oil and gas sector. When crude oil is extracted, it is frequently accompanied by natural gas. This gas is often too remote to reach pipelines or too costly to capture, transport, and sell. As a result, it is simply burned off at the wellhead in a process known as flaring. The scale is staggering: in 2024 alone, more than 150 billion cubic meters of gas were flared worldwide, releasing over 390 million metric tons of CO_2 equivalent.[17] This figure is comparable to the annual emissions of 91 million gas-powered cars,[18] or roughly a third of all vehicles registered in the United States.[19]

To help address this challenge, MARA partnered with NGON to launch a 25-megawatt data center initiative. At oilfields across Texas and North Dakota, natural gas is redirected from flares to MARA's generators, producing on-site power for modular Bitcoin mining data centers. As of August 2025, we estimate the initiative has mitigated over 170,000 metric tons of CO_2 equivalent, comparable to removing nearly 40,000 passenger vehicles from the road for a year.[20]

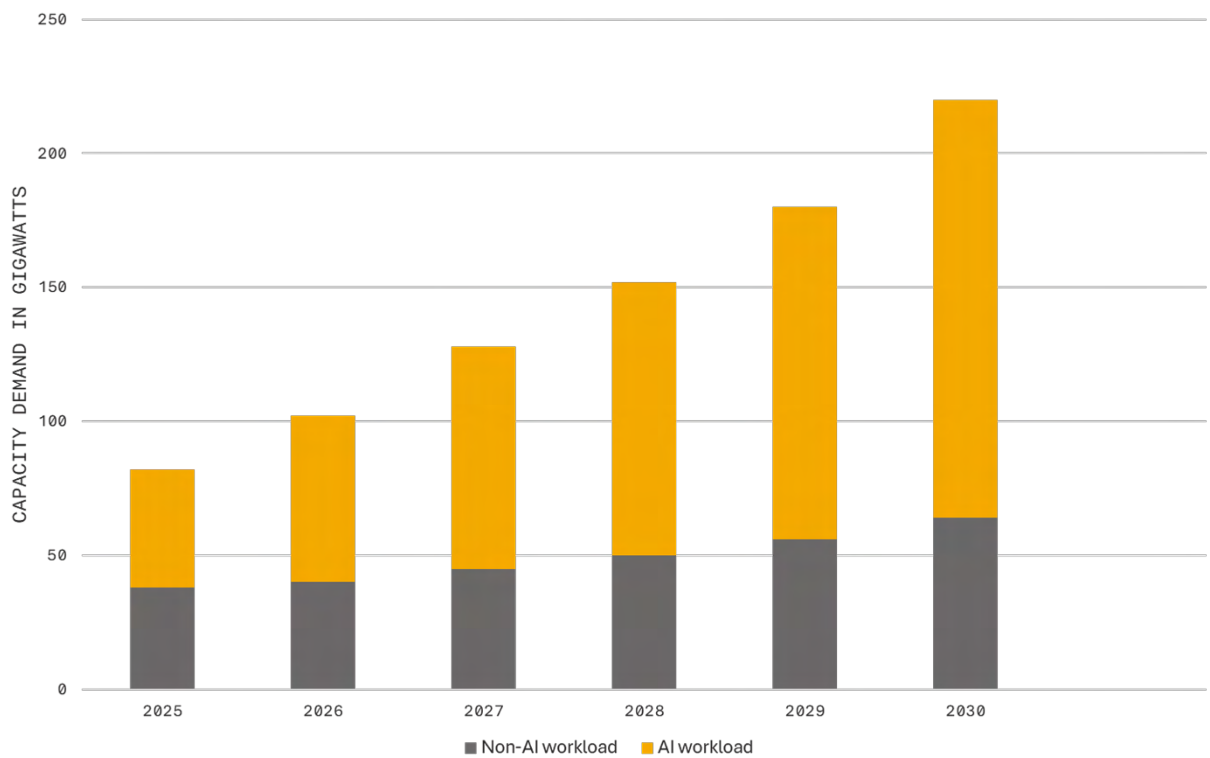


By bringing demand directly to the source, MARA demonstrates that the paradox of progress can be resolved: energy abundance need not create waste or erode returns. With this model, today's surplus becomes the foundation of tomorrow's energy future, where prosperity and sustainability advance together.

The Paradox of Innovation: Creating More Resilient Infrastructure

McKinsey projects global AI data center power demand could grow by three and a half times from 44 GW to 156 GW by 2030.[21] AI has advanced how we live and work. But each leap forward also intensifies stress on resources: data centers often require vast fiber networks, local water supplies, and large volumes of uninterruptible power. This captures the *paradox of innovation*. Progress expands potential, but instead of easing the burden on resources, it often magnifies it.

DATA CENTER POWER DEMAND FROM AI & NON-AI WORKLOADS WORLDWIDE[22]

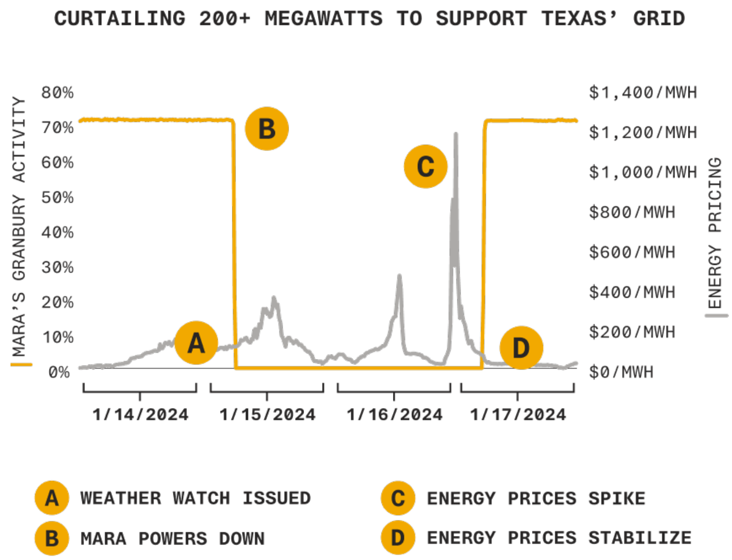


SOURCE: STATISTA

At the same time, the energy sources that supply this growth are increasingly coming from variable renewable sources like wind and solar. As these renewables become a larger proportion of energy production, increasing intermittency can create new forms of instability: generation peaks when the sun shines or the wind blows, then drops when conditions change. This volatility complicates the challenge of meeting scaling demands with energy consumers that have inflexible energy needs. Resource-intensive facilities like AI, hyperscale, and manufacturing have rigid power requirements and cannot simply dial back during tight supply; they are designed to run continuously, making them ill-equipped to absorb renewable variability or relieve grids during peak demand.

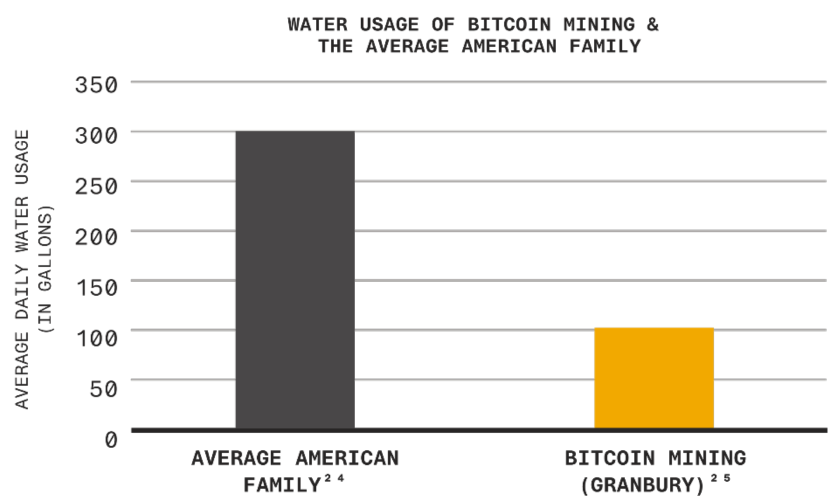
Photo of MARA's Bitcoin mining site in McCamey, Texas, where flexible load helps stabilize the grid.

Bitcoin mining, by contrast, scales in parallel with energy availability. Because electricity is its single largest cost, miners seek underutilized, low-cost resources. When renewable generation floods the system and prices fall, miners ramp up to help capture this supply. When demand tightens and prices rise, miners naturally power down, freeing power when it is needed elsewhere. This market-driven behavior makes Bitcoin mining a uniquely flexible load that helps absorb and manage its fluctuations. By collocating with renewables, mining facilities can act as 'shock absorbers' for supply and demand, potentially offsetting the need for expensive emergency measures like rolling blackouts and peaker plants.



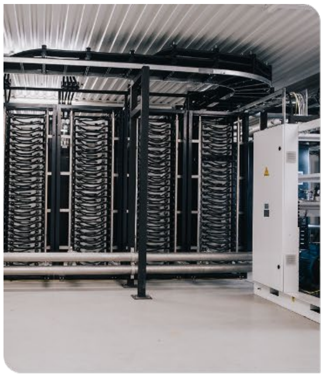
SOURCE: MARA, ENERGY PRICING FROM ERCOT NORTH HUB[23]

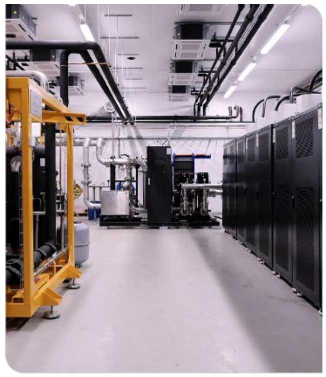
Bitcoin mining also does not require vast fiber networks or water-intensive cooling, and its modular, minimalist design makes it mobile and rapidly deployable. Combined with their ability to scale consumption up or down in real time, this lean footprint allows miners to uniquely adapt to the challenges of different regions — whether that means absorbing wind generation in Texas, balancing grids in the UAE, or monetizing stranded gas in North Dakota.



SOURCE: EPA, COMPANY DATA

Beyond supporting traditional energy sources, MARA has also integrated Bitcoin mining within two of Finland's district heating systems. While common across colder parts of Europe, 90% of global district heating still depends on fossil fuels.[26] This reliance increases emissions, underscoring the urgent need for cleaner, more scalable heat sources. Nearly all the electricity consumed in Bitcoin mining is converted into heat.[27] When captured and reused, this waste heat becomes a low-carbon heat source that can help reduce heating costs. MARA's Finland facilities now deliver megawatts of clean, consistent heat — cutting capital costs, lowering emissions, and replacing legacy fuels.





"[MARA and its partners] produced a constant flow of quality heat energy to our district heating network from their data center. With that heat, we replaced peat, oil, and wood. This development boosts our efforts on replacing fossil fuels and lowering CO_2 emissions. These systems have significantly lowered the total heat production cost in Seinäjoki."

Seinäjoen Energia

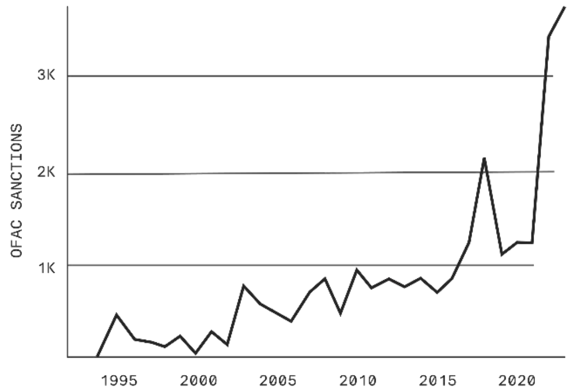
Mikko Mursula,
HEAD OF DISTRICT HEATING UNIT AT SEINÄJOEN ENERGIA.

Views of MARA's Bitcoin mining integrations in Finland: Seinäjoki (left) shows hot water piping to the heat exchanger; Satakunta (right) features mining rack cabinets and heat pump equipment.

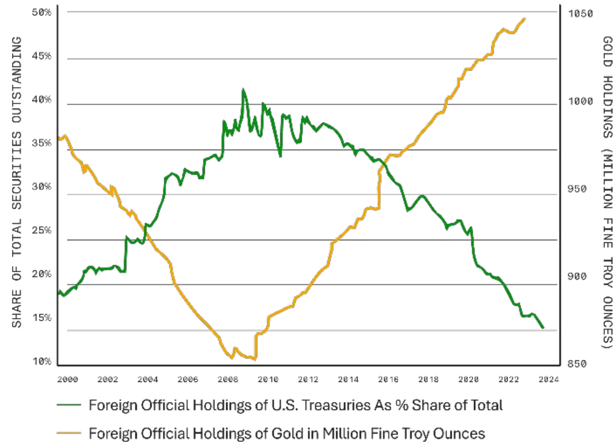
Operating under constraints has made Bitcoin mining efficient, scalable, and resilient. While the growth of various industries increases competition for resources, mining advances by mitigating inefficiencies in existing infrastructure. In doing so, it offers a different answer to the *paradox of innovation*: proof that progress doesn't have to magnify strain but can instead create resilience.

The Paradox of Fragmentation: Reclaiming Decentralized Capital in the Digital Age

Globalism has fueled growth, expanded trade, and increased prosperity. Yet as FII's *Paradox of Fragmentation* points out, the global financial system has entered a new phase of disruption. Sanctions have expanded sharply over the past two decades, leaving a third of all nations subject to restrictions.[28] Combined with rising debt burdens and inflationary pressures, nations are increasingly seeking to de-risk their exposure to any single currency or system. While the global economy remains deeply interconnected, international trade is becoming more complex and difficult to navigate.



SOURCE: WASHINGTON POST



SOURCE: FEDERAL RESERVE, GOLD.ORG

One response to fragmentation has been a renewed interest in gold. For centuries, gold served as a neutral store of value across borders, and today central banks are once again building reserves. Yet gold's physical limitations make it costly to move and secure, concentrating it in a handful of institutions. Those same constraints contributed to the collapse of the gold standard: the supply of gold could not keep pace with global trade, reserves became concentrated in a few countries, and the burden of defending fixed exchange rates created persistent imbalances. In the digital economy of today — faster, larger, and more interconnected than ever — these physical limitations would only be magnified. Until recently, there was no digital counterpart to serve as a neutral, global reserve asset.

Bitcoin provides that alternative: the most credible digital asset and an open monetary network for the digital age. Its supply is fixed, its rules are transparent, and its network has operated without interruption since 2009. Unlike traditional reserves, bitcoin is secured not by intermediaries but by energy and mathematics.

HISTORICAL RETURNS BY MAJOR ASSET CLASS[31]

ETF	ASSET CLASS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
N/A	Bitcoin (BTC)	1473%	186%	5507%	-58%	35%	125%	1331%	-73%	95%	301%	66%	-65%	156%	121%
IWF	US Growth	2.3%	15.2%	33.1%	12.8%	5.5%	7.0%	30.0%	-1.7%	35.9%	38.3%	27.4%	-29.3%	42.6%	33.1%
GLD	Gold	9.6%	6.6%	-28.3%	-2.2%	-10.7%	8.0%	12.8%	-1.9%	17.9%	24.8%	-4.1%	-0.8%	12.7%	26.7%
QQQ	US Nasdaq 100	3.4%	18.1%	36.6%	19.2%	9.4%	7.1%	32.7%	-0.1%	39.0%	48.6%	27.4%	-32.6%	54.9%	25.6%
SPY	US Large Caps	1.9%	16.0%	32.3%	13.5%	1.3%	12.0%	21.7%	-4.6%	31.2%	18.4%	28.7%	-18.2%	26.2%	24.9%
IWD	US Value	0.1%	17.5%	32.1%	13.2%	-4.0%	17.3%	13.5%	-8.4%	26.1%	2.7%	24.9%	-7.7%	11.4%	14.2%
MDY	US Mid Caps	-2.1%	17.8%	33.1%	9.4%	-2.5%	20.5%	15.9%	-11.3%	25.8%	13.5%	24.5%	-13.3%	16.1%	13.6%
IWM	US Small Caps	-4.4%	16.7%	38.7%	5.0%	-4.5%	21.6%	14.6%	-11.1%	25.4%	20.0%	14.5%	-20.5%	16.8%	11.4%
CWB	Convertible Bonds	-7.7%	15.9%	20.5%	7.7%	-0.8%	10.6%	15.7%	-2.0%	22.4%	53.4%	2.2%	-20.8%	14.5%	10.1%
HYG	High Yield Bonds	6.8%	11.7%	5.8%	1.9%	-5.0%	13.4%	6.1%	-2.0%	14.1%	4.5%	3.7%	-11.0%	11.5%	8.0%
PFF	Preferred Stock	-2.0%	18.2%	-1.0%	14.1%	4.3%	1.3%	8.1%	-4.6%	15.9%	7.9%	7.1%	-18.2%	9.2%	7.2%
EEM	Emerging Market Stocks	-18.8%	19.1%	-3.7%	-3.9%	-16.2%	10.9%	37.3%	-15.3%	18.2%	17.0%	-3.6%	-20.6%	9.0%	6.5%
EMB	EM Bonds (USD)	7.6%	16.9%	-7.8%	6.1%	1.0%	9.3%	10.3%	-5.5%	15.5%	5.4%	-2.2%	-18.6%	10.6%	5.5%
BIL	US Cash	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.1%	0.7%	1.7%	2.0%	0.4%	-0.1%	1.4%	4.9%	5.2%
VNQ	US REITs	8.6%	17.6%	2.3%	30.4%	2.4%	8.6%	4.9%	-6.0%	28.9%	-4.7%	40.5%	-26.2%	11.8%	4.8%
EFA	EAFE Stocks	-12.2%	18.8%	21.4%	-6.2%	-1.0%	1.4%	25.1%	-13.8%	22.0%	7.6%	11.5%	-14.4%	18.4%	3.5%
DBC	Commodoties	-2.6%	3.5%	-7.6%	-28.1%	-27.6%	18.6%	4.9%	-11.6%	11.8%	-7.8%	41.4%	19.3%	-6.2%	2.2%
TIP-USA	TIPS	13.3%	6.4%	-8.5%	3.6%	-1.8%	4.7%	2.9%	-1.4%	8.3%	10.8%	5.7%	-12.2%	3.8%	1.7%
BND	US Total Bond Market	7.9%	3.9%	-2.1%	5.8%	0.6%	2.5%	3.6%	-0.1%	8.8%	7.7%	-1.9%	-13.1%	5.7%	1.4%
LQD	Investment Grade Bonds	9.7%	10.6%	-2.0%	8.2%	-1.3%	6.2%	7.1%	-3.8%	17.4%	11.0%	-1.8%	-17.9%	9.4%	0.9%
TLT	Long Duration Treasuries	34.0%	2.6%	-13.4%	27.3%	-1.8%	1.2%	9.2%	-1.6%	14.1%	18.2%	-4.6%	-31.2%	2.8%	-8.1%

In 11 of the past 14 years, bitcoin has been the best-performing major asset class, outpacing equities, bonds, and commodities.[32] This combination of durability, neutrality, and adoption is why governments are increasingly viewing it as a strategic reserve asset. El Salvador was the first nation to embrace bitcoin, adopting it as legal tender and incorporating it into its national reserves. And most recently, the United States has established a strategic reserve, signaling that the world's largest economy sees bitcoin as an asset worth holding. Across both emerging and advanced economies, bitcoin has moved from the margins of finance to the center of economic strategy.

Bitcoin mining is the foundation of the Bitcoin network, converting energy into secure, digital capital. In 2023, Bhutan generated 11 TWh of electricity entirely from hydropower.[33] The country exports up to 80% of this output annually.[34] By directing excess capacity into Bitcoin mining, Bhutan has monetized its excess energy domestically while building a bitcoin reserve valued at roughly 40% of its GDP.[35] El Salvador is leveraging geothermal resources for the same purpose, demonstrating how energy that might otherwise go unused can be converted into a globally liquid asset.

In an era where international trade is increasingly politicized and trust in traditional systems is eroding, bitcoin represents a new kind of reserve asset. In an increasingly fragmented world, bitcoin has the potential to provide the digital foundation for global cooperation.

Conclusion

The paradoxes of progress, innovation, and fragmentation define the challenges of our time. Left unaddressed, they create waste, fragility, and division. Bitcoin mining reframes these same dynamics as opportunities: turning excess energy into value, converting inefficiencies into resilience, and offering decentralized financial rails for a secure reserve asset.

From wind farms in Texas to oilfields in North Dakota, from district heating in Finland to hydropower in Bhutan, energy that might otherwise be stranded or underutilized is transformed into enduring digital capital. Each project illustrates how abundance can be harnessed, rather than lost, to strengthen infrastructure and expand prosperity.

By aligning energy, technology, and finance, Bitcoin mining can turn progress into sustainability, innovation into resilience, and fragmentation into cooperation. In doing so, it offers a blueprint for unlocking abundance in the age of digital capital.

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