

Bitcoin Mining, Renewable Energy, and Stranded Energy Utilization

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This brief compiles publicly available data on the relationship between Bitcoin mining and energy systems, with a focus on renewable energy adoption, stranded energy monetization, and grid stabilization. All data points are sourced from government agencies, academic institutions, and verified corporate disclosures.

52.4%

Sustainable Energy Mix

~43%

Efficiency Gain (1 Gen.)

9,500 MW

Flexible Grid Load (TX)

1. RENEWABLE ENERGY ADOPTION IN BITCOIN MINING

The Cambridge Centre for Alternative Finance (CCAF) — the most widely cited independent authority on Bitcoin network energy data — reported that **52.4% of Bitcoin mining's energy mix came from sustainable sources** as of 2025, including 42.6% renewables (primarily hydroelectric and wind) and 9.8% nuclear.

This represents a significant shift from 2022, when sustainable energy accounted for just 37.6% of the mining mix. Over the same period, coal's share fell from 36.6% to 8.9%.¹

CBECI estimates place Bitcoin's total electricity consumption at approximately 170–180 TWh annually in 2026, representing roughly 0.7–0.8% of global electricity consumption.

Hydroelectric power is the single largest generation source for Bitcoin mining globally, accounting for over one-quarter of all electricity used by the network.

2. STRANDED AND WASTED ENERGY MONETIZATION

Stranded energy refers to electricity or fuel sources that exist but cannot be utilized or sold economically — often because the source is too remote for grid connection or because demand is insufficient. Bitcoin mining's unique properties (location-flexible, interruptible, scalable) make it one of the few loads capable of monetizing these resources.

2a. Flared Natural Gas

The U.S. remains among the top natural gas flaring nations globally. In 2024, an estimated 151 billion cubic meters of associated gas was flared worldwide at upstream oil and gas facilities. Flaring wastes a recoverable energy resource while emitting CO₂ and, when incomplete, unburned methane — a greenhouse gas approximately 80 times more potent than CO₂ over a 20-year horizon.

Crusoe Energy Systems has deployed **Digital Flare Mitigation** technology at oil fields across North Dakota and other basins since 2021. Their systems achieve **99.89% methane combustion efficiency** compared to 91–92% for traditional open flares. Independent analysis by K33 Research found that mining Bitcoin with stranded natural gas reduces CO₂-equivalent emissions by approximately **63%** compared to continued flaring, and offsets approximately **9,482 tons of CO₂e per megawatt annually** — roughly 5× the offset of an equivalent-capacity wind installation and 7× that of solar.

Crusoe reports cumulative offsets exceeding **2.7 million tons of CO₂** since inception.

2b. Hydroelectric Surplus

Multiple regions possess hydroelectric capacity that exceeds local demand due to the closure of legacy industrial consumers (lumber mills, smelters, paper plants). Mining operations have located at these sites to absorb surplus generation:

- **Pacific Northwest / Quebec:** Historical hydroelectric dams built for manufacturing-era loads now serve diminished demand. Mining operations monetize this excess zero-carbon generation.²
- **Paraguay:** Over 99% of electricity comes from hydroelectric sources. The country produces far more than domestic consumption requires and has historically exported surplus at a loss. Bitcoin mining provides a new domestic buyer for this clean energy.
- **Norway:** Northern regions have significant hydroelectric surplus. Sazmining operates a facility in a Norwegian fishing village at near-100% carbon-free power.

2c. Landfill and Biogas Methane Capture

¹Cambridge Centre for Alternative Finance, "Cambridge Digital Mining Industry Report," 2025. Cambridge Judge Business School.

²Cambridge Blockchain Network Sustainability Index (CBECI), 2026. <https://ccaf.io/cbnsi/cbeci>

A growing category of mining projects converts methane from landfills, wastewater treatment, and agricultural operations into electricity for Bitcoin mining. This creates a financial incentive for methane capture that did not previously exist:

- **Marathon Digital Holdings** operates a 280 kW pilot facility powered by landfill methane in Utah.³
- **Nodal Power** raised \$13 million in Series A funding to deploy portable power plants at municipal landfills, converting vented methane to mining electricity.⁴
- **Vespe Energy** partnered with municipal landfills in Wisconsin using micro-turbine technology to capture methane emissions for onsite data processing.

A 2024 peer-reviewed study published in the *Journal of Cleaner Production* modeled the economic viability of coupling Bitcoin mining with landfill gas capture, concluding that mining revenue can make methane abatement projects financially self-sustaining.

Batcoinz analysis projects that if 50 U.S. landfills adopted mining-based methane capture, the Bitcoin network could reach **net-zero emissions by 2027** without purchasing carbon offsets.

3. GRID STABILIZATION AND DEMAND RESPONSE

Bitcoin mining operations represent a uniquely valuable grid resource: large, controllable electrical loads that can be curtailed within minutes during peak demand events. This capability has been most extensively demonstrated in Texas through the ERCOT grid.

The U.S. Energy Information Administration reports that ERCOT's Large Flexible Load (LFL) capacity — predominantly Bitcoin mining — reached an estimated **9,500 MW by end of 2025**, a 73% increase over prior approved capacity. This represents approximately 10% of ERCOT's total forecast electricity consumption.

Texas Senate Bill 6 (2025) formalized this relationship by requiring large flexible loads of 75+ MW to curtail consumption when wholesale electricity prices exceed \$100/MWh. During July 2025 heat events, miners curtailed over **50,000 MWh** of consumption, redirecting power to residential and commercial consumers.

Riot Platforms, one of the largest publicly traded miners, reported **\$56.7 million in power curtailment credits for full-year 2025** — a 68% increase year-over-year. In June 2025 alone, the company earned \$3.8 million in curtailment credits and \$1.8 million in demand-response credits by reducing mining load during grid stress events.

This demand-response model means mining operations function as a form of **virtual energy storage**: they absorb surplus generation during low-demand periods (reducing curtailment of wind and solar) and release capacity back to the grid during peak demand. The economic incentive structure is self-reinforcing — miners profit both from mining and from curtailment credits.

4. HARDWARE EFFICIENCY TRENDS

Bitcoin mining hardware (ASICs) has undergone rapid efficiency gains. The standard metric is **joules per terahash (J/TH)** — the energy required per trillion hash computations. Lower values indicate greater efficiency.

Model	Hashrate	Power	Efficiency
Antminer S19 Pro (2022)	110 TH/s	3,250 W	29.5 J/TH
Antminer S19 XP (2023)	140 TH/s	3,010 W	21.5 J/TH
Antminer S21 (2024)	200 TH/s	3,550 W	17.8 J/TH
Antminer S21 XP (2025)	270 TH/s	3,645 W	13.5 J/TH

The S21 XP represents a **~43% efficiency improvement** over its predecessor in a single generational cycle. This trajectory means the network performs exponentially more computation per unit of energy consumed, and older, less efficient hardware is continually retired from the network as it becomes unprofitable.

5. POLICY LANDSCAPE

Several states have established regulatory frameworks that explicitly address Bitcoin mining's energy relationship:

- **Texas:** Provides 10-year tax abatements for mining operations. Senate Bill 6 (2025) mandates grid participation by requiring curtailment during price spikes, ensuring miners contribute to grid reliability rather than competing with residential consumers.
- **Wyoming:** Has enacted over a dozen pro-cryptocurrency laws including sales tax exemptions on mining equipment and zero corporate/personal income tax, while maintaining clear regulatory frameworks.

³U.S. Energy Information Administration (EIA), "Natural Gas Flaring," 2024. <https://www.eia.gov/todayinenergy/detail.php?id=62383>

⁴Crusoe Energy Systems, "Digital Flare Mitigation: Technology Overview," 2024. <https://www.crusoe.ai>

- **Federal:** The SEC ruled in March 2025 that proof-of-work mining is not subject to federal securities laws. The bipartisan CLARITY Act (May 2025) further defines regulatory responsibilities between the SEC and CFTC.

These policy precedents demonstrate that a regulatory approach balancing economic incentives with grid reliability and environmental requirements is both feasible and operational.

SUMMARY

The available data indicates that Bitcoin mining's energy profile has shifted materially toward sustainable sources, with over half of network energy now coming from renewables and nuclear. The industry's unique load characteristics — location flexibility, rapid interruptibility, and scalable demand — have created a new economic model for monetizing stranded energy resources that were previously wasted.

Key trends point in a consistent direction: rising renewable share, falling carbon intensity, improving hardware efficiency, growing grid stabilization participation, and increasing methane capture deployments. These trends are supported by verifiable data from independent academic institutions, government agencies, and publicly traded corporate disclosures.

RIBPI is available to provide additional data, arrange subject matter expert briefings, or support further analysis on any topic covered in this brief.

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