# Bankrolling Bitcoin Pollution:

## *How Big Finance Supports a New Climate Threat*

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*Bitcoin Big Horn Data Center in Hardin, Montana*

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Greenpeace is an independent campaigning organization that uses peaceful protest and creative communication to expose global environmental problems and to promote solutions that are essential to a green and peaceful future.

**Bankrolling Bitcoin Pollution: How Big Finance Supports a New Climate Threat**
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# Introduction

The early days of mining Bitcoin at home on your laptop are long gone. Bitcoin mining has grown into a large commercial industry dominated by publicly traded companies that operate large-scale mining facilities, often using as much electricity as a small city. **In 2023, Bitcoin mining globally consumed an estimated 121 TWh of electricity, similar to the entire gold mining industry or a mid-sized industrial country like Poland, which is primarily generated by fossil fuels.**[1] Bitcoin mining companies rely on access to capital markets to build new digital mining facilities—essentially large data centers, and purchase specialized computer equipment which use all of that electricity and cause a large amount of carbon emissions, while creating a lifeline for fossil fuels. Yet, there's been little scrutiny of how investments from traditional finance companies are enabling Bitcoin mining companies' carbon-intensive operations. Banks, asset managers, insurers, venture capital firms, and others need to be held accountable for their support of polluting Bitcoin mining and must start taking responsibility for enabling this growing climate threat that is out-of-step with corporate climate goals and net zero pathways.

The growth of Bitcoin, and its Proof-of-Work (PoW) system that uses digital "mining" to validate transactions and secure data, relies on financial support from large banks and asset managers.[2] **Despite the guise of Bitcoin being independent from the mainstream financial system, the industry is deeply connected to traditional finance for Bitcoin mining companies to access capital and to enable trading and investing in Bitcoin.** For example, BlackRock, the world's largest asset manager, was the third largest investor in Bitcoin mining companies in 2022 and recently launched an investment fund, called an Exchange Traded Product (ETP), tied to the price of Bitcoin that has garnered billions of dollars and led to a spike in the price of Bitcoin.[3]

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[1] Cambridge Centre for Alternative Finance at the Judge Business School, University of Cambridge. "Greenhouse Gas Emissions Comparisons - Country Comparisons." The Cambridge Bitcoin Electricity Consumption Index (CBECI). https://ccaf.io/cbeci/ghg/comparisons; "Cambridge" in subsequent footnotes

[2] For a more detailed explanation of Proof-of-Work consensus mechanism and Bitcoin mining, see: https://cleanupbitcoin.com/resources; DeRoche, Mandy, Jeremy Fisher, Nick Thorpe and Megan Wachspress.September 2022. *The Energy Bomb: How Proof-of-Work Cryptocurrency Mining Worsens the Climate Crisis and Harms Communities Now*. Earthjustice and Sierra Club. https://earthjustice.org/wp-content/uploads/energy_bomb_bitcoin_white_paper_101322.pdf

[3] "Bitcoin Price Surges as BlackRock ETF Hits $1.3 Billion All-Time High." March 5, 2024. *Nasdaq.* https://www.nasdaq.com/articles/bitcoin-price-surges-as-blackrock-etf-hits-%241.3-billion-all-time-high

However, there is little reporting about how financial companies are propping up the Bitcoin mining industry and financing their climate polluting operations. The Bitcoin mining industry is also notorious for its lack of transparency. Thus, we investigated the financial services companies providing investments and support to Bitcoin mining companies. We also linked those investments and services to the climate impacts of mining companies using an innovative approach to estimating their energy use and carbon emissions. **We found that Trinity Capital, Stone Ridge Holdings, BlackRock, Vanguard, and MassMutual are the top five financiers of carbon pollution from Bitcoin mining companies, accounting for over 1.7 million metric tons $CO_2$ in 2022—equal to the emissions from over 335,000 American homes using electricity for a year.**[4]

We also provide some of the first independent estimates of company-level carbon emissions by Bitcoin mines, particularly the emissions generated by adding demand from large Bitcoin mining facilities to electrical grids. **We find that Bitcoin mining companies Core Scientific, Riot Platforms, Bitfarms, Hut 8, and Marathon Digital generated the most carbon emissions** in 2022 and the collective emissions caused by their additional energy demand was equal to the emissions of nearly 850,000 American homes using electricity for a year.[5] **All 20 publicly-traded Bitcoin mining companies contributed as much climate disrupting carbon to the atmosphere in 2022 as two coal power plants in a year, over 7.8 million metric tons $CO_2$.**[6] We assess the consequential emissions associated with mining companies rather than only their average, location-based emissions, in order to highlight the true impact of their industrial-scale power demand. Despite some miners' claimed use of renewable electricity, their impact on the grid often means fossil fuel plants need to fire up to satisfy demand.

[4] GHG equivalencies calculated using U.S. EPA tool: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results

[5] The top 5 Bitcoin mining companies created 4,294,402 metric tons $CO_2$ in 2022. GHG equivalencies calculated using U.S. EPA tool: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results

[6] Total estimated consequential emissions from all 20 Bitcoin mining companies was 7,817,773 metric tons $CO_2$ in 2022. GHG equivalencies calculated using U.S. EPA tool: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results

# Bitcoin's Climate and Transparency Problems

According to estimates from the Cambridge Center for Alternative Finance, the global Bitcoin mining network consumed 95.53 TWh of electricity in 2022 and 121.13 TWh in 2023 which generated 48.41 and 61.38 million metric tons $CO_2$, respectively.[7] That's as much electricity and greenhouse gas (GHG) emissions as many medium-sized countries or physically mining gold.[8] And with that electricity use comes a country-sized carbon footprint. Researchers estimate Bitcoin's climate impact relative to its market value is comparable to beef production and gasoline from crude oil.[9] Bitcoin's environmental impacts have also worsened as the industry has grown.[10]

Bitcoin uses so much electricity because of its Proof-of-Work (PoW) consensus mechanism. Cryptocurrencies work outside a centralized authority like a bank or government, and instead operate through a decentralized and collectively-maintained database, or digital ledger, that stores a record of all transactions. This requires a way to reach consensus on the validity of transactions and prevent fraud. Bitcoin uses PoW, unlike many other cryptocurrencies, which requires participants (known as miners) to put in computational "work" to demonstrate their credibility and protect the system's integrity. The work involves racing to guess the right number to solve a complex algorithm which requires many specialized computers using lots of electricity. The winner gets to validate a new set, or "block," of Bitcoin transactions and is rewarded with newly "mined" Bitcoins.

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[7] Cambridge Centre for Alternative Finance at the Judge Business School, University of Cambridge. Cambridge Bitcoin Electricity Consumption Index. "Total Bitcoin Electricity Consumption, yearly." https://ccaf.io/cbnsi/cbeci; Cambridge Centre for Alternative Finance at the Judge Business School, University of Cambridge. Cambridge Bitcoin Electricity Consumption Index, Greenhouse Gas Emissions Index. "Total Bitcoin Greenhouse Gas Emissions, yearly." https://ccaf.io/cbnsi/cbeci/ghg

[8]Cambridge Centre for Alternative Finance at the Judge Business School, University of Cambridge. "Greenhouse Gas Emissions Comparisons - Country Comparisons." The Cambridge Bitcoin Electricity Consumption Index (CBECI). https://ccaf.io/cbeci/ghg/comparisons.

[9] Jones, Benjamin A., Andrew L. Goodkind, and Robert P. Berrens. 2022. "Economic Estimation of Bitcoin Mining's Climate Damages Demonstrates Closer Resemblance to Digital Crude than Digital Gold." *Scientific Reports* 12(1):14512. https://www.nature.com/articles/s41598-022-18686-8; Goodkind, Andrew L., Benjamin A. Jones, and Robert P. Berrens. 2020. "Cryptodamages: Monetary Value Estimates of the Air Pollution and Human Health Impacts of Cryptocurrency Mining." Energy Research & Social Science 59:101281.https://www.sciencedirect.com/science/article/abs/pii/S2214629619302701; de Vries, Alex. 2021. "Bitcoin Boom: What Rising Prices Mean for the Network's Energy Consumption." Joule 5:509–13. https://www.sciencedirect.com/science/article/pii/S2542435121000830.

[10] Jones, Benjamin A., Andrew L. Goodkind, and Robert P. Berrens. 2022. "Economic Estimation of Bitcoin Mining's Climate Damages Demonstrates Closer Resemblance to Digital Crude than Digital Gold." Scientific Reports 12(1):14512. https://www.nature.com/articles/s41598-022-18686-8.

*Bitcoin Mining in Rockdale, Texas*
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**Energy-hungry miners are straining electrical grids across the U.S. and world, keeping fossil fuel plants running and draining electricity when more is needed to power electrification of housing, transportation, and manufacturing to meet global climate targets.**[11] The U.S. Energy Information Agency (EIA) estimates that annual electricity use from cryptocurrency mining—primarily Bitcoin, given its the largest cryptocurrency and one of a few using PoW—already comprises 0.6% to 2.3% of U.S. electricity consumption in 2023.[12] The large demand from miners can even drive up electricity prices for regular consumers.[13]

Yet, even these often-cited figures from academics and government agencies on the electricity and carbon footprint of Bitcoin are only best guesses.[14]

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[11] International Energy Agency. January 2024. "Electricity 2024: Analysis and forecast to 2026." https://iea.blob.core.windows.net/assets/6b2fd954-2017-408e-bf08-952fdd62118a/Electricity2024-Analysisandforecastto2026.pdf; Frazier, Melanie. February 23, 2024. "The rise of crypto mines in the South raises concerns for the electric grid, rates." NPR. https://www.npr.org/2024/02/23/1233355167/the-rise-of-crypto-mines-in-the-south-raises-concerns-for-the-electric-grid-rate; Milman, Oliver. February 18, 2022. "Bitcoin miners revived a dying coal plant – then CO2 emissions soared." The Guardian. https://www.theguardian.com/technology/2022/feb/18/bitcoin-miners-revive-fossil-fuel-plant-co2-emissions-soared

[12] Morey, Mark, Glenn McGrath, and Hiroaki Minato. February 1, 2024. Tracking electricity consumption from U.S. cryptocurrency mining operations." *U.S. Energy Information Administration.* https://www.eia.gov/todayinenergy/detail.php?id=61364#:~:text=Our%20preliminary%20estimates%20suggest%20that,2.3%25%20of%20US.%20 electricity%20 consumption.&text=This%20additional%20electricity%20use%20has,cost%2C%20reliability%2C%20and%20emissions.

[13] Dance, Gabriel. January 3, 2024. "The Real-World Costs of the Digital Race for Bitcoin." *New York Times.* https://www.nytimes.com/2023/04/09/business/bitcoin-mining-electricity-pollution.html

[14] Chamanara, Sanaz, S. Arman Ghaffarizadeh, and Kaveh Madani. 2023. "The Environmental Footprint of Bitcoin Mining Across the Globe: Call for Urgent Action." *Earth's Future* 11(10):e2023EF003871. doi: 10.1029/2023EF003871; Siddik, Md Abu Bakar, Maria Amaya, and Landon T. Marston. 2023. "The Water and

That's because there is no reliable data on the industry's energy use and subsequent carbon emissions since there is a lack of standardized reporting and disclosure from Bitcoin mining companies.[15] The Bitcoin mining sector does not follow widely accepted and verified systems for reporting GHG emissions and other environmental impacts. In fact, the industry vehemently resisted when U.S. regulators instituted a survey of mining companies about energy use motivated by concerns about rising electricity demand, grid stability, and carbon emissions.[16] **The industry's lack of disclosure and transparency enables Bitcoin mining companies to avoid accountability and obscures the scale of Bitcoin's climate problem.**

Big financial companies have faced pressure to disclose and reduce investments in polluting industries, particularly fossil fuel extraction and production. There has been some, although not nearly enough, progress in holding the financial industry accountable for investments driving the climate crisis.[17] However there has been virtually no scrutiny of how these banks, asset managers, insurance companies and others are fueling a new climate threat—Bitcoin mining. Financial companies have been silent about the emissions enabled by investments in Bitcoin miners despite many companies reporting on so-called scope 3 emissions linked to investments and lending for other energy intensive industries.

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Carbon Footprint of Cryptocurrencies and Conventional Currencies." *Journal of Cleaner Production* 411:137268. doi: 10.1016/j.jclepro.2023.137268; Wendl, Moritz, My Hanh Doan, and Remmer Sassen. 2023. "The Environmental Impact of Cryptocurrencies Using Proof of Work and Proof of Stake Consensus Algorithms: A Systematic Review." *Journal of Environmental Management* 326:116530. doi: 10.1016/j.jenvman.2022.116530; Krause, Max. 2018. "Quantification of Energy and Carbon Costs for Mining Cryptocurrencies." Nature Sustainability 1. doi: 10.1038/s41893-018-0152-7; de Vries, Alex, Ulrich Gallersdörfer, Lena Klaaßen, and Christian Stoll. 2022. "Revisiting Bitcoin's Carbon Footprint." *Joule* 6(3):498–502. doi: 10.1016/j.joule.2022.02.005.

[15] The emissions from miners using electricity would be scope 2 emissions and are largely not being reported. Scope 1 are direct emissions which apply to a few mining companies that own and operate power plants. Those companies do report emissions from their power plants, but don't clearly specify what amount of capacity is being used for Bitcoin mining.

[16] Kearney, Laila. February 28, 2024. "Crypto miner lawsuit sets back US effort to track booming power use." *Reuters.* https://www.reuters.com/legal/crypto-miner-lawsuit-sets-back-us-effort-track-booming-power-use-2024-02-28/

[17] For examples of reporting and research on financing for fossil fuels, see: "Banking on Climate Chaos." May 13, 20204. https://www.bankingonclimatechaos.org/wp-content/uploads/2024/05/BOCC_2024_vF1.pdf; Rothfeder, Jeffrey, and Christopher Maag. February 2, 2023. "How Wall Street's fossil-fuel money pipeline undermines the fight to save the planet." *Fortune.* https://fortune.com/longform/wall-street-banks-finance-fossil-fuel-emissions-oil-companies/

*Activists Bring "Skull of Satoshi" to Fidelity's Offices in New York City*
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While some mainstream financial companies have stayed away from crypto due to financial and regulatory risks, the wall between mainstream finance and crypto is quickly crumbling.[18] And even some companies, like Vanguard, that don't provide services to buy, sell, and hold cryptocurrencies, are still invested in Bitcoin mining companies.[19] Investors need to know about their exposure to risky Bitcoin mining companies that depend on cheap electricity often generated by fossil fuels and will struggle to adapt to the transition to renewables and carbon reduction policies as well as disruptions from climate change-fueled extreme weather.[20] **Banks and asset managers have a duty to disclose risks to their shareholders and clients who are currently missing vital information on the climate risks from Bitcoin.** As the Bitcoin industry grows and becomes more enmeshed in traditional financial markets, it's past time for more transparency about its environmental impacts.

There is also a troubling trend of the Bitcoin industry making false and greenwashing claims regarding Bitcoin's environmental impact. Assertions about Bitcoin mining's supposed environmental and social benefits, like

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[18] Schrager, Allison. January 26, 2024. "Crypto Is Going Mainstream, Which Means It's Over." *Bloomberg*. https://www.bloomberg.com/opinion/articles/2024-01-26/bitcoin-etf-crypto-is-going-mainstream-which-means-it-s-over; Morrow, Allison. March 5, 2024. "Bitcoin surges to new record high as mainstream money flows into crypto." *CNN*. https://www.cnn.com/2024/03/04/business/bitcoin-record-high/index.html

[19] Vanguard. March 19, 2024. "Vanguard's perspective on bitcoin ETFs." https://investor.vanguard.com/investor-resources-education/news/vanguards-perspective-on-bitcoin-etfs.

[20] Pan, David. September 8, 2023. "Texas Bitcoin Miners Are Shuttering Operations While Power Crisis Intensifies." *Bloomberg*. https://www.bloomberg.com/news/articles/2023-09-08/texas-bitcoin-miners-are-shuttering-operations-as-power-crisis-intensifies

supporting the renewable energy transition, lack empirical support and fail to address the actual ways mining generates carbon emissions, strains electrical grids, and consumes large amounts of water. Taking a playbook from the tobacco and fossil fuel industry, Bitcoin mining leaders have gone so far as to publish misleading studies in predatory scientific journals written by industry representatives in an attempt to paint a green image.[21] Such papers are commonly written by people who work for Bitcoin mining companies or trade associations with blatant conflicts of interest and are submitted to journals that are known for poor peer-review processes, or upload work to online repositories with no peer-review system that are then marketed to the public as rigorous science. These articles have been written to present Bitcoin's energy-intensive mining as good for the environment by incentivizing renewable and stranded energy use and providing stability to power grids. However, they fail to acknowledge that these ideas are either speculative, contested, or false.

Speculative narratives and faulty claims obscure and distract from the realities of Bitcoin mining's environmental impacts. The lack of reputable electricity and emissions reporting also makes it hard for investors, stakeholders, and regulators to make informed decisions.

Thus, we counter industry claims about boosting renewable energy by assessing how adding large-scale electricity demand from miners impacts the energy system, often requiring fossil fuel plants to operate. We estimate the emissions that could have been avoided without large Bitcoin mining facilities existing and show how additional load from miners can divert renewable energy from other users, actually leading to a more carbon-intensive electrical grid.

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[21] For example, see: Rudd, Murray A., Lee Bratcher, Simon Collins, David Branscum, Matthew Carson, Shaun Connell, Elliot David, Magdalena Gronowska, Sebastien Hess, Austin Mitchell, Matt Prusak, Kyle Schneps, Maxim Serezhin, Scott A. Wolfe, and Dennis Porter. 2023. "Bitcoin and Its Energy, Environmental, and Social Impacts: An Assessment of Key Research Needs in the Mining Sector." *Challenges* 14(4):47. https://www.mdpi.com/2078-1547/14/4/47; Rudd, Murray, Jones, Matthew, Sechrest, Daneil, Batten, Daniel, & Porter, Dennis. (2024). An integrated landfill-gas-to-energy and Bitcoin mining model. In SSRN Electronic Journal. Elsevier BV. https://doi.org/10.2139/ssrn.4810964;
Analysis of the journal's publisher MDPI see: Oviedo-García, M. Ángeles. 2021. "Journal Citation Reports and the Definition of a Predatory Journal: The Case of the Multidisciplinary Digital Publishing Institute (MDPI)." Research Evaluation 30(3):405–19. https://academic.oup.com/rev/article/30/3/405/6348133

*March to End Fossil Fuels in New York*
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## Estimating Bitcoin Carbon Emissions and Investments

In partnership with financial research experts at nonprofit Profundo and using electricity grid emissions data and analytical support from nonprofit WattTime, we developed an innovative approach for estimating the energy consumption and carbon emissions from Bitcoin mining companies, and used industry-standard methods to calculate the financed and facilitated carbon emissions attributed to lending, shareholding, bondholding, and underwriting for Bitcoin miners from financial services companies.

First, we generated a list of private and public Bitcoin mining companies but found that only 20 mining companies disclosed enough information about both their business operations and finances to estimate energy use, carbon emissions, and financial support from financiers.[22]

[22] Profundo identified financial data for 29 Bitcoin mining companies, but only enough data on operations to identify the number of Bitcoin mined and make emissions estimates for 20 companies. Throughout the report, we present findings for those 20 companies only (Appendix 1).

Then, using companies' financial filings, news reports, and other documents, Profundo identified how many Bitcoin each company mined in 2022.[23] The 20 companies accounted for 16% of all Bitcoin minted that year. Using the Cambridge Center for Alternative Finance's Bitcoin Electricity Consumption Index, we estimated how much energy was used on average globally to mine a single bitcoin in 2022.[24] That allowed us to create a standard estimate of how much energy was used by each mining company in 2022 since most companies reported little to no verifiable data on their actual energy consumption. The energy use and emissions of the Bitcoin network have grown since 2022, particularly because this covers a period of low prices for Bitcoin, so the situation has only gotten worse. To calculate the company's carbon emissions, we reviewed company documents for information about the size (power capacity) and location of their mining facilities to estimate the emissions generated.

WattTime estimated both the attributional (location-based) and consequential emissions from Bitcoin mining operations. Attributional emissions reflect the emissions allocated to a mining company based on the average emissions factor of the grid where each mining facility was located.[25] However, we also wanted to capture the real-world consequential emissions impact caused by adding Bitcoin miners to energy grids, which can be assessed using marginal emissions factors. When a Bitcoin mine adds new load to an electrical grid, typically fossil fuel plants need to generate more electricity to meet the additional demand. Thus, the broader impact of new industrial-scale electricity demand is to increase emissions, even on grids with large amounts of renewable energy capacity. We accounted for this consequential impact using marginal emissions factors.

Marginal emissions factors can vary significantly from average emissions factors, depending on the electricity generation mix and the order in which different power sources are dispatched to meet demand. In most places, including the U.S., there is a limited amount of power supplied by renewable technologies on most major electric grids. When these renewables reach their maximum capacity, fossil fuel sources such as gas or coal are typically

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[23]Data informing this report is available to the public on GitHub: https://github.com/greenpeaceusa/bankrolling-bitcoin-pollution/

[24] Cambridge Digital Assets Programme (CDAP) at the Cambridge Centre for Alternative Finance. The Cambridge Bitcoin Electricity Consumption Index (CBECI). https://ccaf.io/cbnsi/cbeci

[25] The average emissions rate is a calculation of the average emissions rate of all the electricity generated on the local grid at a certain time. Average emissions generally are a way to allocate responsibility for emissions evenly, instead of causally. To estimate the location-based attributional emissions, WattTime used the method developed by the GHG protocol, available at: https://ghgprotocol.org/sites/default/files/Scope2_ExecSum_Final.pdf

used to supply the remaining electricity demand. This means that when additional power demand is added to a grid, fossil fuel sources make up the difference beyond what renewable sources can supply, and act as a "marginal" supply for energy. For example, if the marginal source of electricity is a coal-fired power plant, the marginal emissions would be higher than the average emissions, which may include a mix of less emissions-intensive sources like renewables.[26] We found that some Bitcoin mines reported using clean energy such as hydropower from their energy providers, however it is important to understand that this also reduces the amount of renewable electricity available to other grid users, meaning marginal sources like gas and coal still need to increase generation in response.

Throughout the report, we primarily report consequential emissions estimates, but attributional emissions estimates are included in Appendix 2, as well as a thorough description of how emissions and financing were estimated.[27] The overall results for the largest financed and facilitated emissions, and company emissions are similar for both approaches even though the absolute emissions amounts are higher for the consequential emissions estimates. There are also some small differences in the relative emissions of miners depending on which approach is used.

Finally, researchers at Profundo used financial databases as well as company annual reports, financial statements, company registries, and media archive to identify financiers of Bitcoin mining companies and to detail investments (shareholdings and bond holdings) and credit (loans and underwriting services) provided to miners.[28] This data was used to calculate the attribution factors and estimate the financed and facilitated emissions of financial institutions investing in Bitcoin miners. The value of reported investments and credit were attributed to company carbon emissions using the Partnership Carbon Accounting Financials (PCAF) methodology, which is a standard for GHG accounting among financial institutes.[29]

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[26] WattTime and Rocky Mountain Institute. "On the Importance of Marginal Emissions Factors for Policy Analysis." https://www.bloomenergy.com/wp-content/uploads/watttime_the_rocky_mountain_institute.pdf

[27] Based on marginal emissions analysis and the average estimate of electricity use from Cambridge, which is how we primarily present carbon emissions in the report. The Marginal Operating Emissions Rate (MOER) represents the emissions rate of the electricity generator(s) that are responding to changes in load on the local grid at a certain time. The MOER includes the effects of renewable curtailment and import/export between grid regions. The units of MOER are the amount of pollution per unit of energy (lbs/MWh).

[28] See additional details about methodology and data in Appendix 1.

[29] PCAF Standards for GHG calculation and reporting include industry-supported methods for accounting for financed and facilitated emissions, as well as insurance-assisted emissions which we do not explore.

# Financing Bitcoin's Climate Damage

Our analysis reveals that **Trinity Capital, Stone Ridge Holdings, BlackRock, Vanguard, and MassMutual financed the most carbon emissions from Bitcoin mining companies in 2022** (Figure 1).[30] Trinity Capital, a publicly-traded venture capital firm, led the way with 473,000 metric tons $CO_2$ from its $60 million in loans to Hut 8 and Core Scientific—that's equivalent to emissions from over 93,000 U.S. homes using electricity for a year.[31] Overall, **the identified investments and lending for Bitcoin miners in 2022 financed and facilitated 4.7 million metric tons $CO_2$** (Figure 1). That's like the emissions from over 900,000 U.S. homes consuming electricity for a year, nearly the number of households in Houston, Texas.[32]

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Unsurprisingly, several crypto-friendly companies were the biggest financiers of emissions from Bitcoin miners. Stone Ridge Asset Management is a leading player in Bitcoin investing and has a subsidiary, New York Digital Investment Group (NYDIG), that is one of the largest providers of Bitcoin and

[30] That ranking is based on consequential emissions estimates, but for attributional location-based emissions, BlackRock, Vanguard, and MassMutual have more emissions than Stone Ridge, which falls to 5th place.

[31] GHG equivalencies calculated using, U.S. EPA. "Greenhouse Gas Equivalencies Calculator." https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[32] GHG equivalencies calculated using, U.S. EPA. "Greenhouse Gas Equivalencies Calculator." https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator; Houston had 947,632 households in 2022 and 998,195 housing units as of 2020, data from: U.S. Census Bureau. "Profile: Houston city, Texas." https://data.census.gov/profile/Houston_city,_Texas?g=160XX00US4835000

crypto investing services and holds billions of dollars worth of Bitcoin.[33] Stone Ridge was the second largest financier of Bitcoin miner's emissions, 438,000 metric tons $CO_2$ in 2022, from loans to four mining companies worth $226 million. However, when using an average emissions approach, Stone Ridge was fifth, behind BlackRock and Vanguard (Appendix 2 Figure A1, Table A1).

We also find that big Wall Street companies are investing in Bitcoin mining and enabling the industry's pollution. This reflects how traditional finance is increasingly entering the cryptocurrency market in search of profits despite the climate, financial, and regulatory risks. Many household names are among the companies financing and facilitating the most emissions from

Bitcoin miners including BlackRock, Vanguard, MassMutual, State Street, Morgan Stanley, and Invesco who collectively financed over 1 million metric tons $CO_2$ emissions in 2022, about 22% of all the financed and facilitated emissions identified in our study (Figure 1). BlackRock had the third most financed emissions, with Vanguard very close behind.[34] State Street's financed emissions were due to large share and bond holdings in mining companies while MassMutual issued loans to miners in 2022.

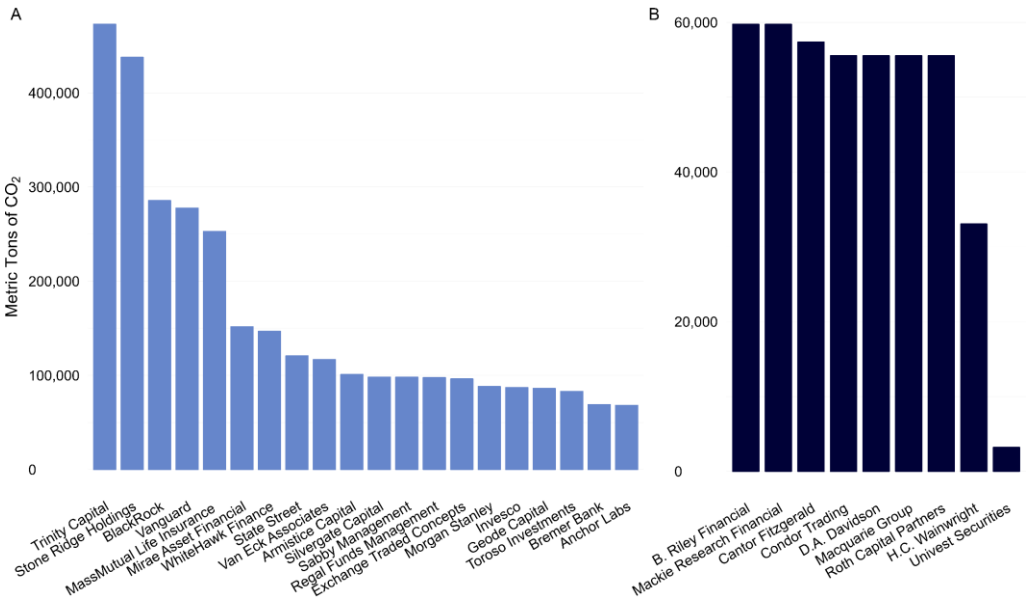


Figure 1. The largest financed (A) and facilitated (B) consequential emissions by financial institutions based on identified investments and underwriting to Bitcoin mines in 2022.

[33] del Castillo, Michael. October 13, 2020. "Stone Ridge Reveals $115 Million Bitcoin Investment As Part Of Billion-Dollar Spinoff." *Forbes*. https://www.forbes.com/sites/michaeldelcastillo/2020/10/13/stone-ridge-reveals-115-million-bitcoin-investment-as-part-of-billion-dollar-spin-off/?sh=48bd81179850

[34] Based on attributional emissions estimates, BlackRock and Vanguard were second and third in financed emissions, respectively.

| Financial Company | Financed Emissions (metric tons $CO_2$) |
|---|---|
| Trinity Capital | 473,000 |
| Stone Ridge Holdings | 438,000 |
| BlackRock | 285,000 |
| Vanguard | 278,000 |
| MassMutual | 253,000 |
| Mirae Asset Financial | 152,000 |
| WhiteHawk Finance | 147,000 |
| State Street | 121,000 |
| Van Eck Associates | 117,000 |
| Armistice Capital | 101,000 |
| Silvergate Capital | 98,000 |
| Sabby Management | 98,000 |
| Regal Funds | 98,000 |
| Exchange Traded Concepts | 96,000 |
| Morgan Stanley | 88,000 |
| Invesco | 87,000 |
| Geode Capital | 86,000 |
| Toroso Investments | 83,000 |
| Bremer Bank | 69,000 |
| Anchor Labs | 68,000 |
| **Total** | **3,236,000** |

| Financial Company | Facilitated Emissions (metric tons $CO_2$) |
|---|---|
| B. Riley Financial | 60,000 |
| Mackie Research Financial | 60,000 |
| Cantor Fitzgerald | 57,000 |
| Condor Trading | 56,000 |
| D.A. Davidson | 56,000 |
| Macquarie Group | 56,000 |
| Roth Capital Partners | 56,000 |
| H.C. Wainwright | 33,000 |
| Univest Securities | 3,000 |
| **Total** | **437,000** |

Table 1. The largest financed and facilitated consequential emissions by financial companies with identified investments, credit, or underwriting in Bitcoin mines. The top 5 financiers financed and facilitated about 40% of the total estimated emissions from this research—over 1.7 million metric tons $CO_2$.

## Top Investors and Creditors in Bitcoin Mining

Many Bitcoin mining companies used equity financing—creating and selling shares or stock in the company—to access capital to fund acquisitions, build facilities, and purchase more ASICs, specialized Bitcoin mining computers.[35] Mining companies have also used debt financing, namely issuing bonds, to raise capital. Bonds are similar to a loan in that the company pays bondholders back over time with a specific rate of interest. Once bonds are issued, they are split into shares and then bought and sold by investors, much like stocks. However, miners largely relied on selling stock as we found that 90% of investment financing was through shareholdings and 10% from bond holdings. The biggest buyers of bonds and stocks are asset managers that oversee money for company 401(k)s, pension funds, individual wealthy investors, endowments, and others. **Energy-intensive mining companies like Marathon Digital and Riot Platforms relied on hundreds of millions in equity and debt financing in 2022 to expand their mining capacity** (Figure

[35] Blocksbridge Consulting. February 22, 2024. "Equity investment is flooding into mining stocks." *Miner Weekly*. https://blocksbridge.substack.com/p/equity-investment-bitcoin-mining

2).[36] In fact, of the miners receiving financing through investments, Marathon Digital and Riot Platforms received almost 70% of the financing while the top 4 received over 80% showing that the majority of investments were concentrated on a few major mining companies (Figure 2).

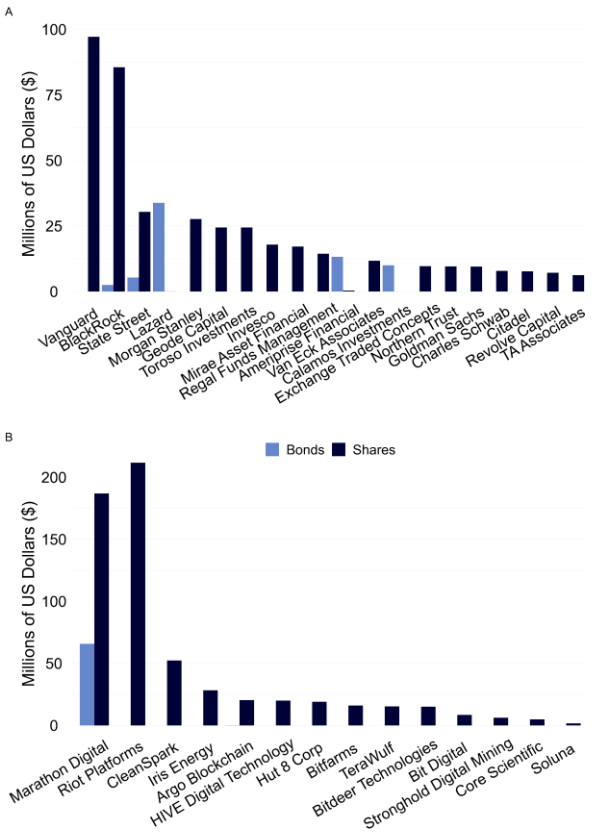


Figure 2. (A) The amount of identified investments provided by the twenty highest-investing financial institutions to focal Bitcoin mines. (B) The amount of identified investments received by each Bitcoin mining company investigated in this report. Marathon Digital and Riot Platforms together received over two-thirds (69.1%) of all investments and we did not identify investments for all 20 mines.

**The largest overall investors in Bitcoin mining companies were Vanguard and BlackRock**, but other large firms like State Street, Morgan Stanley, Ameriprise, Invesco, and Goldman Sachs were also among the largest (Figure 2). We identified over $670 million dollars invested into the 20 Bitcoin mining companies we investigated. This means that the savings of everyday people could be exposed to Bitcoin mining companies through their retirement and investment accounts with companies like Vanguard, BlackRock, and State Street, the so-called "big three" index fund managers. These companies issue popular investment vehicles like mutual funds and ETPs that are used by millions and manage money for big companies and public pensions.[37] In 2022, those three firms managed about $22 trillion, a massive amount that was equivalent to more than half of the value of all shares in S&P 500 companies.[38]

Creating and selling new shares and bonds relies on underwriting services typically provided by investment banks who evaluate the company's value and facilitate sales. Companies depend on these services to access capital markets which has enabled Bitcoin miners to grow by purchasing new equipment, acquiring land to build mining facilities, and funding construction. In total, we identified $462 million in underwriting for Bitcoin miners in 2022—no underwriting services were identified from 2012 to 2021.

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[36] *ibid*

[37] McLaughlin, David and Annie Massa. January 9, 2020. "The Hidden Dangers of the Great Index Fund Takeover." *Bloomberg*. https://www.bloomberg.com/news/features/2020-01-09/the-hidden-dangers-of-the-great-index-fund-takeover

[38] Manjoo, Farhad. May 12, 2022. "What BlackRock, Vanguard and State Street Are Doing to the Economy." *New York Times*. https://www.nytimes.com/2022/05/12/opinion/vanguard-power-blackrock-state-street.html

We found that a handful of mid-sized U.S. banks are providing the bulk of underwriting services, including Cantor Fitzgerald, B. Riley Financial, Mackie Research Financial, Roth Capital, H.C. Wainwright, and D.A. Davidson (Figure 3). H.C. Wainwright provided $161 million in underwriting while Cantor Fitzgerald provided $59 million and B. Riley and Mackie Financial both provided $44 million. Underwriting from those six financial services companies alone facilitated 322,000 metric tons $CO_2$ (Figure 1, Table 1). Meanwhile, these banks are earning revenue with little scrutiny for the environmental and community damages or disclosures to investors and regulators about the climate risks.

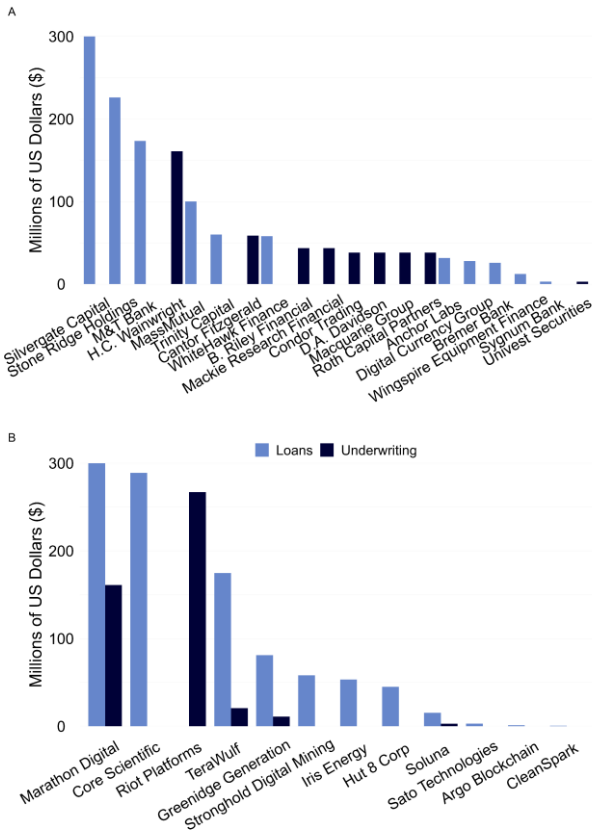


Figure 3. (A) The amount of identified credit provided by the twenty financial institutions with the greatest credit amount given to focal Bitcoin mines. (B) The amount of identified credit received by each Bitcoin mining company investigated in this report. Not all Bitcoin miners received credit during the study period based on our research.

Many mining companies are also funding their operations with loans from a core group of lenders from the U.S. that includes niche crypto-focused firms and some larger traditional finance companies. In total, we identified lending of over $1 billion dollars across Bitcoin mines we researched. Until very recently, Bitcoin mining companies were considered very risky for financial institutions, thus most of the company's financing was through private investors and joint venture capital. Since the Bitcoin mining industry remains new and small compared to other major industries like oil and gas or steel, there was relatively less lending, particularly large, syndicated loans offered by groups of lenders.

We found that the top five lenders were **Silvergate (the crypto-friendly bank that collapsed in 2023), Stone Ridge, M&T Bank, H.C. Wainwright, and MassMutual which combined lent miners over $960 million** from 2012 to 2022, the large majority of all the identified loans that year. Stone Ridge was the second largest lender issuing $226 million in loans to four mining companies, including Greenidge Generation, Iris, and Core Scientific—some of the most carbon polluting companies in our study. In total, we identified $1.02 billion in loans granted to Bitcoin miners from 2019 to 2022, in the last four years of data collected from 2012-2022. The total identified financing in 2022 was $1.02 billion out of the total identified financing of $1.48 billion. (Figure 3).

M&T Bank and MassMutual are large publicly-traded companies that don't have a reputation for supporting cryptocurrencies, but issued loans to miners in 2022. MassMutual lent Core Scientific $100 million in 2022 which financed over 250,000 metric tons $CO_2$.[39] M&T lent $174 million to Terawulf which facilitated 31,800 metric tons $CO_2$ (Appendix 2 Figure A2).[40]

We also find that only a small group of mining companies are receiving loans and underwriting services. Marathon Digital Holdings, Core Scientific, Riot Platforms, TeraWulf, and Greenidge Generation are the top financing recipients and these five companies received more than 80% of the identified financing from 2012-2022.

2022, the year our data covers, was also a period of turmoil in the Bitcoin mining industry as many companies struggled with large amounts of debt, largely from payments on bonds and interest on loans, and a period of slumping Bitcoin prices.[41] Miners relied on credit and access to capital markets to weather the turmoil in Bitcoin's price during what was dubbed the "crypto winter."[42] Core Scientific, which had the largest mining capacity (or hashrate) among publicly traded miners, even declared bankruptcy in 2022.[43] Thus, lending and investing in Bitcoin miners is financially risky beyond the climate risks and threat to sustainability and climate goals.

## Contradicting Corporate Climate Commitments

Investments, loans, and underwriting to polluting Bitcoin mining companies is out of step with the carbon reduction targets and sustainability pledges from financial services companies. **In our study, 540 financial institutions financed or facilitated emissions by enabling Bitcoin mining operations.** Financed emissions and risky loans tied to Bitcoin miners are also largely going unreported and unacknowledged. Financial services firms are resisting reporting their financed and facilitated emissions, particularly in the U.S., but even companies that do disclose this data have not mentioned the

[39] Based on consequential emissions analysis and Cambridge's best guess electricity use estimates.

[40] Terawulf. "An Overview of Terawulf's Facilities." https://www.terawulf.com/terawulf-facilities/

[41] Mellerud, Jaran.December 23, 2022. "Which Public Bitcoin Miners Owe the Most Money?" https://hashrateindex.com/blog/which-public-bitcoin-miners-owe-the-most-money/

[42] Mark, Julian and Gerrit De Vynck. December 18, 2022. "'Crypto winter' has come. And it's looking more like an ice age." *Washington Post.* https://www.washingtonpost.com/business/2022/12/18/crypto-winter-ftx-collapse-bitcoin-prices/

[43] Sigalos, MacKenzie. December 22, 2022. "Bitcoin miner Core Scientific is filing for Chapter 11 bankruptcy — but plans to keep mining." *CNBC.* https://www.cnbc.com/2022/12/20/bitcoin-miner-core-scientific-filing-for-bankruptcy-will-keep-mining.html

### Financing Fossil Fuel Power: Big Horn County, Montana

A dirty coal-fired power plant, the Hardin Generating station in Big Horn County, Montana, has been kept alive by supplying electricity to Marathon Digital's nearby Bitcoin mine. The Hardin coal plant's closure was announced in 2017 after years of declining use. However, in 2021, Marathon started mining next door and the plant's output increased 816%.[46] Now closure plans appear to be on hold. During the first three months of 2022, the plant was on pace to increase output another 45% which meant even more air pollution than the 304 tons of sulfur dioxide and 245 tons of nitrogen oxides emitted in 2021.[47]

Big Wall Street companies are helping fund Marathon's carbon and other air pollution emissions that harm public health and contribute to the climate crisis by investing millions of dollars in the company. In 2022, Vanguard had $37.5 million worth of shares, BlackRock had over $33 million in shares and bonds, State Street had $15.75 million in shares and bonds, Morgan Stanley had over $10 million in shares, and Ameriprise had $13.4 million in bonds which collectively financed 62,000 metric tons $CO_2$. That's despite BlackRock's statements about reducing investments in coal.[48] Investment bank H.C. Wainwright also provided $161 million in underwriting—a vital service enabling Marathon to access capital through the stock market in the first place—which facilitated 33,000 metric tons $CO_2$.

*Bitcoin Big Horn Data Center in Hardin, Montana*
© Janie Osborne / Greenpeace

emissions tied to Bitcoin.[44] Thus, the climate risks from investing in Bitcoin mining companies are not being fully acknowledged. The business model of miners who rely on cheap fossil fuel energy could be upended by policies like carbon taxes or strong renewable energy portfolio standards. Their operations are also threatened by extreme weather and unstable electrical grids.[45] This means that regulators, shareholders, and individual and institutional investors aren't being informed about climate, not to mention financial and regulatory, risks to make informed decisions and policy.

**BlackRock is purportedly a leader in ESG investing but was responsible for the 3rd most carbon emissions from its investments in Bitcoin miners and had the most among big Wall Street firms.** This contradicts BlackRock's sustainability efforts and climate goals. BlackRock is a signatory to the Net Zero Asset Managers initiative, which includes pledging to support net zero emissions by 2050 in line with efforts to limit warming to

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[44] Laidlaw, Jennifer, Giulia Hallqvist, Francesca Jaworska, and Wera von der Osten. January 20, 2023. "Financed emissions are missing from many firms' net zero plans." *S&P Global.* https://www.spglobal.com/esg/insights/financed-emissions-are-missing-from-many-firms-net-zero-plans

[45] Pan, David. February 6, 2023. "Riot's Bitcoin Mining Still Crimped by December Storm in Texas." *Bloomberg.* https://www.bloomberg.com/news/articles/2023-02-06/riot-riot-bitcoin-mining-machines-are-offline-after-texas-winter-storm; Quinton, Davis. June 10, 2022. "How extreme Texas weather impacts the bitcoin mining industry." *The Block.* https://www.theblock.co/post/151012/how-extreme-texas-weather-impacts-the-bitcoin-mining-industry

[46] Lacey, Anthony and Jessica Hernandez. April 5, 2023. "Big air quality problems in Big Sky Country." *Proof of problems: Bitcoin mining's pollution toll on U.S. communities.* Environmental Working Group. https://www.ewg.org/research/proof-problems-bitcoin-minings-pollution-toll-us-communities/montana

[47] *ibid*

[48] BlackRock. "Sustainability as BlackRock's New Standard for Investing." https://www.blackrock.com/au/individual/blackrock-client-letter

1.5°C.[49] BlackRock also promotes reporting of emissions as a member of the Task Force on Climate-related Financial Disclosures (TCFD), a widely accepted approach to climate reporting, and a signatory to the UN's Principles for Responsible Investment.[50] While BlackRock has voiced support for corporate climate disclosures, that is something sorely missing in the Bitcoin mining industry.[51]

**Vanguard's extensive shareholdings in Bitcoin mining companies financed the fourth most emissions, which stands in sharp contrast to the company's stated skepticism of Bitcoin and cryptocurrencies as well as its climate goals.[52]** Vanguard, unlike most Bitcoin miners, does disclose its scope 1, 2, and some 3 emissions and issues TCFD reports. Yet a glaring gap is that Vanguard doesn't have targets to cut scope 3 emissions tied to its billions of dollars of investments, including in Bitcoin miners. This means that Vanguard is not addressing the primary way it and other asset managers are funding the climate crisis.[53]

In 2021, MassMutual boasted of being the first U.S.-based life insurance company to create a 2050 net zero goal for its investment portfolio.[54] The company is also a signatory of the UN-supported Principles for Responsible Investment (PRI), an international global network of asset managers, owners and service providers working to implement responsible investment practices. Yet in 2022 the company had the 5th most financed emissions in Bitcoin mining companies (Figure 1).

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[49] The Net Zero Asset Managers. "The Net Zero Asset Managers Commitment." https://www.netzeroassetmanagers.org/commitment/

[50] BlackRock. "BlackRock's 2030 net zero statement." https://www.blackrock.com/corporate/sustainability/2030-net-zero-statement

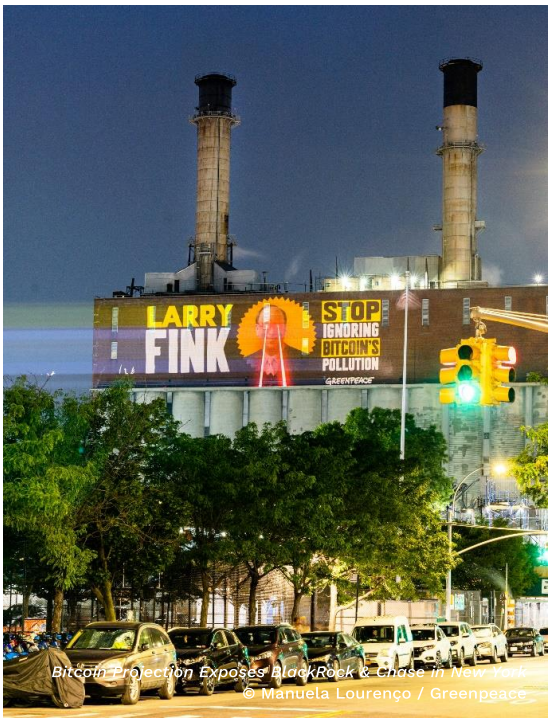
[51] BlackRock. August 2022. "BlackRock supports consistent climate related disclosures; urges global coordination." https://www.blackrock.com/corporate/literature/whitepaper/spotlight-blk-supports-consistent-climate-related-disclosures-issb-august-2022.pdf

[52] Vanguard. January 24, 2024. "No bitcoin ETFs at Vanguard? Here's why." https://corporate.vanguard.com/content/corporatesite/us/en/corp/articles/no-bitcoin-etfs-at-vanguard-heres-why.html; Vanguard. "Sustainability at Vanguard." https://corporate.vanguard.com/content/corporatesite/us/en/corp/who-we-are/we-care-about/sustainability.html

[53] Alcoba, Natalie. August 2, 2023. "The incredible shrinking climate ambitions of the world's largest asset managers." *Corporate Knights*. https://www.corporateknights.com/category-finance/the-incredible-shrinking-climate-ambitions-of-the-worlds-largest-asset-managers/

[54] Massachusetts Mutual Life Insurance Company. July 12th, 2022. "MassMutual releases inaugural Sustainability Report." https://www.massmutual.com/about-us/news-and-press-releases/press-releases/2022/07/massmutual-releases-inaugural-sustainability-report

Mirae Asset Financial Group had the 6th most financed emissions and is one of the largest Korean financial companies and a leader in mutual funds (Figure 1). Mirae reports on environmental issues through annual sustainability reports and is a signatory to the UN-PRI Principles and a supporter of TCFD.[55] In 2023 the company joined the Net Zero Asset Managers Initiative and has set net zero targets for investments based on 1.5°C pathways. Yet, the company has not addressed how extensive shareholdings in Bitcoin miners contradicts these goals and principles.



*Bitcoin Projection Exposes BlackRock & Chase in New York*
© Manuela Lourenço / Greenpeace

Even some of the smaller and crypto-friendly financial companies have at least minimal climate goals and sustainability reporting. Stone Ridge is late to the game on sustainability but in 2024 issued its first annual sustainability report. It included a Task Force for Climate-Related Financial Disclosures (TCFD) Report and received a B score on CDP Climate Change Disclosure which included some scope 3 emissions.[56] Trinity Capital however doesn't have carbon reduction targets or issue annual sustainability reports. Unfortunately, that's indicative of venture capital firms that are behind other financial sectors in taking climate action.[57] Trinity is avoiding scrutiny for the carbon footprint of its investments and failing to report climate risks to its shareholders.

## Polluting Bitcoin Mining Companies

Our data provides some of the first independent estimates of company-level electricity use and carbon emissions among Bitcoin miners. We find that Core Scientific, Riot Platforms, Bitfarms, Hut 8, and Marathon Digital were the top 5 emitters in 2022 based on consequential emissions, combining to cause nearly 4.3 million metric tons $CO_2$ (Figure 4, Table 2).[58] **We estimate that**

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[55] Mirae Asset Global Investments. 2023. "Policy on Responsible Investing." https://investments.miraeasset.com.hk/docs/responsible-policy.pdf

[56] Stoneridge. "2023 Sustainability Report: Moving Mobility Forward." https://www.stoneridge.com/wp-content/uploads/2024/04/2023-Stoneridge-Sustainability-Report.pdf

[57] Roston, Eric. April 25, 2023. "Venture Capital Has a New Net-Zero Alliance." *Bloomberg.* https://www.bloomberg.com/news/articles/2023-04-25/venture-capital-focuses-on-climate-change-with-new-net-zero-alliance

[58] Our estimates of electricity use and carbon emissions estimates might be lower than the actual operations of mining companies because we are unable to account for hosting services, essentially mining

**placing the additional electricity consumption of all 20 companies on the electrical grid caused as much carbon emissions as the electricity used by 1.5 million U.S. homes in a year, more than all the houses in Chicago, Illinois.**[59] Based on attributional emissions estimates, the top 5 were still Core Scientific and Riot Platforms but followed by Marathon Digital, Hut 8 Corp, and CleanSpark (Appendix 2 Figure A3). While the 20 companies included in our analysis are amongst the largest mining operations, they still only represent a fraction of the emissions from the entire global Bitcoin mining network. These companies accounted for about 16% of the Bitcoin minted in 2022, thus the true scale of Bitcoin's climate damage is much larger.[60]

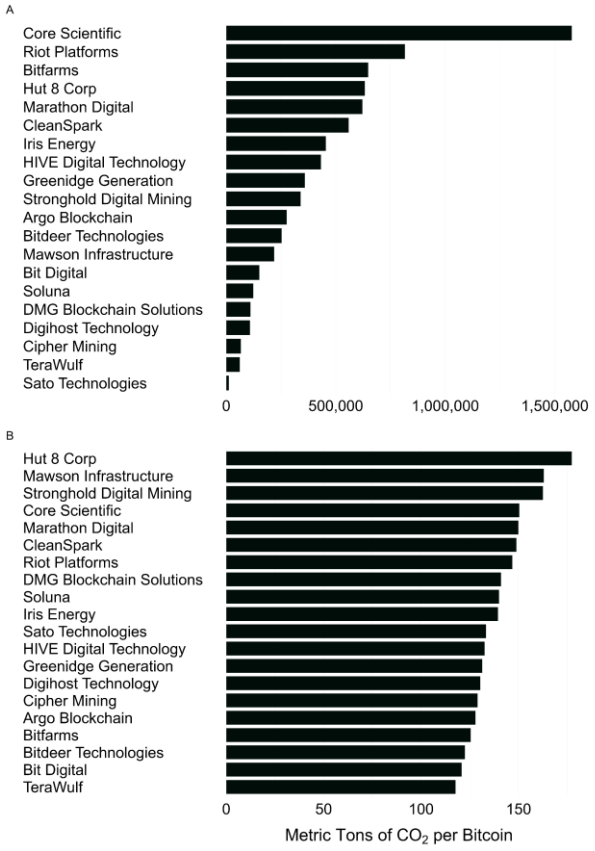


Figure 4. (A) Consequential emissions estimated for focal Bitcoin mining companies for the fiscal year 2022. Emissions calculations were done by WattTime with support from Profundo and Greenpeace. (B) The carbon intensity of mining operations was estimated as the consequential emissions per Bitcoin mined by each miner in 2022.

**Hut 8, Mawson Infrastructure, Stronghold Digital Mining, and Core Scientific also had the most carbon-intensive mining operations based on consequential carbon emissions per amount of Bitcoin mined in 2022** (Figure 4).[61] Thus, while Core Scientific and Riot Platforms generated the most carbon emissions largely due to mining the most Bitcoin, some companies had relatively more carbon-intensive operations and greater emissions per Bitcoin mined. This is likely due to the location of their mines and the energy-mix on the grid or fuel sources for mines connected directly to power plants, like Stronghold Digital that owns a power plant

on behalf of other companies for a fee. For companies that own power plants, we are only estimating the emissions due to mining Bitcoin, not the full operation of the plant to generate electricity.

[59] Our range of estimates are 4,052,535 to 18,226,925 metric tons $CO_2$ in 2022 using a consequential emissions approach. GHG equivalencies calculated using, U.S. EPA. "Greenhouse Gas Equivalencies Calculator." https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator; In 2020 Chicago had 1,262,612 housing units, data based on: U.S. Census Bureau. "Profile: Chicago City, Illinois."https://data.census.gov/profile/Chicago_city,_Cook_County,_Illinois?g=060XX00US1703114000

[60] According to Blockchain.com (https://www.blockchain.com/explorer/charts/total-bitcoins), on Jan 1 2022, there were 18,915,693.75 bitcoins in circulation and by December 31, 2022, there were 19,247,031.25. That translates into a total of 331,337.5 bitcoins minted in 2022. Our analysis found that all 20 Bitcoin mining companies earned 54,445 bitcoin in 2022.

[61] Using attributional emissions estimates, Hut 8, Marathon Digital, CleanSpark, and Mawson Infrastructure have the most emissions-intensive operations (Appendix 2 Figure A4).

burning waste coal.[62] Analysis by the Sierra Club finds that air pollution from Stronghold's Scrubgrass coal plant led to four premature deaths per year.[63] Unlike total carbon emissions, we didn't see as much variation in the carbon intensity of miners' operations.[64]

Bitcoin mining companies often promote vague claims about using "clean" energy in an attempt to greenwash their operations. Yet, most of the companies don't actually report their energy consumption and carbon emissions, and don't follow standardized protocols for disclosing climate and environmental impacts that are used by many other companies. Thus, we sought a consistent way to compare the emissions between companies and estimate the consequential emissions of adding this new load to the grid, not just the attributional emissions for a mining facility. This approach shows how miners can hamper grid decarbonization efforts.

*Scrubgrass Generating Power Plant in Pennsylvania*
© Scott Goldsmith / Greenpeace

[62] Wang, Boen. November 7, 2022 "How One Pennsylvania Company is Using Waste Coal to Mine Bitcoin." *Allegheny Front*. https://www.alleghenyfront.org/stronghold-digital-mining-bitcoin-waste-coal-power-plant-pennsylvania/

[63] Sierra Club. 2023. "Out of Control: The Deadly Impact of Coal Plant Pollution." https://coal.sierraclub.org/deadly-impact-of-coal-pollution

[64] There is more variation in carbon intensity when using attributional location-based emissions since some companies have a large difference between attributional and consequential emissions.

| Mining Company | Consequential Emissions (metric tons $CO_2$) | Attributional Emissions (metric tons $CO_2$) |
|---|---|---|
| Core Scientific | 1,577,000 | 999,000 |
| Riot Platforms | 815,000 | 510,000 |
| Bitfarms | 648,000 | 67,000 |
| Hut 8 Corp | 633,000 | 458,000 |
| Marathon Digital | 621,000 | 492,000 |
| CleanSpark | 559,000 | 400,000 |
| Iris Energy | 454,000 | 74,000 |
| HIVE Digital Technology | 432,000 | 136,000 |
| Greenidge Generation | 359,000 | 177,000 |
| Stronghold Digital Mining | 339,000 | 203,000 |
| Argo Blockchain | 276,000 | 178,000 |
| Bitdeer Technologies | 253,000 | 117,000 |
| Mawson Infrastructure | 219,000 | 130,000 |
| Bit Digital | 151,000 | 97,000 |
| Soluna | 124,000 | 81,000 |
| DMG Blockchain Solutions | 111,000 | 11,000 |
| Digihost Technology | 108,000 | 65,000 |
| Cipher Mining | 66,000 | 49,000 |
| TeraWulf | 62,000 | 32,000 |
| **Total** | **7,818,000** | **4,276,000** |

Table 2. Consequential and attributional emissions estimated from 20 focal mining companies, using the "best guess" scenario by CBECI.

**Even when Bitcoin miners are connected to energy grids with relatively large amounts of renewable energy, adding new industrial-scale demand can increase carbon emissions because gas and coal plants operate more to meet the additional demand.** We find that companies on grids with lots of regional hydropower, like in British Columbia, Canada, have a large difference between the estimated consequential and attributional emissions. For example, we estimate that Bitdeer, who has operations near hydropower plants in Washington State and Norway, had attributional emissions of 67,000 metric tons $CO_2$ but the consequential emissions—the actual impact across the entire grid system—were 648,000 metric tons $CO_2$. Bitfarms has a mine in Farnham, Quebec where the attributional emissions were estimated to be only 590 metric tons $CO_2$ but the consequential emissions were much larger, over 85,000 metric tons $CO_2$. The actual real-world emissions caused by Bitcoin mining are often 10x to 100x greater than the attributional emissions. Relying on attributional accounting—or worse, market-based accounting—conveniently allows Bitcoin miners to hide their true carbon pollution impacts.

Another way Bitcoin miners claim to use renewable energy and have low carbon emissions is by purchasing Renewable Energy Credits (RECs) and reporting "market-based" emissions based on RECs and carbon offsets. However, RECs are notoriously unregulated and often do little or nothing to

### Financing Fossil Fuel Power: Texas

Texas is a hub for Bitcoin mining and since 2021, when China kicked out Bitcoin miners, around 2,300 MW of Bitcoin mining facilities have been built in the state.[67] Standing out in this Bitcoin boom is Riot Platforms' sprawling facility near Rockdale that had the largest carbon emissions in 2022 among facilities owned by publicly traded Bitcoin miners. Wall Street firms are also helping bankroll this pollution. Vanguard, BlackRock, Morgan Stanley, and State Street have the largest financed emissions in Riot, accounting for 526,000 metric tons $CO_2$ which is the amount of carbon emitted from 100,000 U.S. homes using electricity for a year.[68] Riot is also expanding into another, possibly even bigger, mine in Texas which is facing community resistance. Residents are worried about the noise pollution, heavy water usage, spiking electricity prices, and public subsidies.[69] Local opposition is part of a broader movement in Texas and nationally to stop the growth of Bitcoin mining that is straining the electrical grid and pushing up electricity prices for ratepayers.[70]

*Coalition against Cryptomining Protest in Texas*
© Brittany Hallberg / Greenpeace

cut carbon emissions or spur renewable energy development.[65] Researchers have found that RECs are actually a major barrier to meeting carbon reduction targets and keeping global warming below 2°C.[66] When rosy corporate claims about purchasing RECs are left aside, we find emissions-intensive operations that rely on fossil fuel energy.

CleanSpark, for example, touts its commitment to sustainability and doing "responsible" Bitcoin mining.[71] The company reports using 94% clean energy in 2022 but without any detailed information or emissions estimates following standard GHG accounting measures. Our analysis paints a very different picture. We estimate that additional electricity demand from the companies' facilities led to over 500,000 metric tons $CO_2$ emissions in 2022, the 6th most out of the publicly-traded miners, and enough to offset the emissions savings from 147 wind turbines.[72]

[65] For examples of critiques of RECs see: Osaka, Shannon and Hailey Haymond. June 21, 2023. "Buying renewable energy doesn't mean what you think." *Washington Post.* https://www.washingtonpost.com/climate-environment/2023/06/21/renewable-energy-credits-certificates-greenwashing/; July 22, 2023. "It's Not Easy Going Green: There's a way to 'fight' climate change that's cheap, popular and completely ineffective." *Reveal.* https://revealnews.org/podcast/its-not-easy-going-green/; Elgin, Ben and Sinduja Rangarajan. October 31, 2022. "What Really Happens When Emissions Vanish." *Bloomberg.* https://www.bloomberg.com/news/features/2022-11-01/intel-p-g-cisco-among-major-companies-exaggerating-climate-progress

[66] Bjørn, Anders, Shannon M. Lloyd, Matthew Brander, and H. Damon Matthews. 2022. "Renewable Energy Certificates Threaten the Integrity of Corporate Science-Based Targets." *Nature Climate Change* 12(6):539–46. https://www.nature.com/articles/s41558-022-01379-5

[67] Ferman, Mitchell. October. 3, 2022. "Cryptocurrency miners line up to come to Texas, and rural counties are welcoming them." *Texas Tribune*. https://www.texastribune.org/2022/10/03/texas-cryptocurrency-mining-bitcoin/

[68] GHG equivalencies calculated using, U.S. EPA. "Greenhouse Gas Equivalencies Calculator." https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[69] Singh, Gigi. October 27, 2023. "Texan Activists To Bitcoin Miners: Don't Mess with Texas' Water and Electricity." *Greenpeace USA*. https://www.greenpeace.org/usa/news/texan-activists-to-bitcoin-miners-dont-mess-with-texas-water-and-electricity/

[70] Fernholz, Tim. April 10, 2023. "Bitcoin mining has raised Texas electricity prices 5%." *Quartz.* https://qz.com/bitcoin-mining-has-raised-texas-electricity-prices-5-1850319961

[71] CleanSpark. "ESG." https://investors.cleanspark.com/governance/esg/

[72] GHG equivalencies calculated using, U.S. EPA. "Greenhouse Gas Equivalencies Calculator." https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Miners claiming to use renewable energy by simply hooking up to the grid near renewable sources ignores their broader impacts on emissions. Connecting large-scale Bitcoin mines to relatively clean grids will not advance decarbonization and renewable energy development since these facilities primarily tap into already existing or planned renewable generation. Unless Bitcoin mining companies are actually paying for new renewable generation that would not have been built otherwise and generating more electricity than they consume, they aren't helping decarbonize the grid. **Bitcoin mines can actually drain renewable energy that is needed for other socially-necessary uses like heating and cooling houses, especially given the rapid electrification needed to achieve net zero pathways**.[73]

# Recommendations to Clean-up Bitcoin

Cleaning-up Bitcoin is possible. However, it will require major stakeholders in Bitcoin, like the financial services companies invested in mining companies, to take responsibility and start working on solutions. Fundamentally, cryptocurrencies don't need to use the energy-intensive PoW consensus mechanism, a system to validate transactions and secure the network's data[74]. Changing how Bitcoin's underlying system works can address the root cause of the problem. But currently even assessing the scope of the problem is difficult due to the lack of accurate and reliable data. This lets miners and financial companies avoid scrutiny and downplay Bitcoin's threat to the climate. Thus, immediate actions are needed to increase reporting and disclosure from the industry which can inform other regulatory and technological efforts to slash Bitcoin's emissions.

## Reporting and Disclosure

Transparency is a necessary first step toward understanding the size of Bitcoin's environmental problems. **Bitcoin miners need to disclose data about their energy use and carbon emissions, including scope 1-3 emissions,** following globally accepted standards including the GHG Protocol and other environmental reporting protocols like Sustainability Accounting Standards Board (SASB) standards and International Sustainability Standards

[73] Popovich, Nadja and Brad Plumer. April 14, 2023. "How electrification became a major tool for fighting climate change." *New York Times.* https://www.nytimes.com/interactive/2023/04/14/climate/electric-car-heater-everything.html

[74] For more information on the Proof-of-Work consensus mechanism, see: Nevil, S. May 17, 2024. What Is Proof of Work (PoW) in Blockchain? *Investopedia*. https://www.investopedia.com/terms/p/proof-work.asp

Board Standards.[75] While some miners report "market-based" emissions based on accounting tricks to hide emissions like buying RECs, these are not a replacement for disclosing the actual location-based or consequential emissions excluding offsets. The GHG Protocol, for example, requires that companies reporting market-based emissions also disclose location-based emissions. It's time for the energy-intensive Bitcoin mining industry to come out of the shadows and follow the broader business community, including other energy and carbon-intensive industries, on sustainability reporting and setting scientific and measurable climate targets. Our analysis relied on estimates and assumptions because there is no verifiable data on electricity consumption and emissions.

*Bitcoin Projection Exposes BlackRock & Chase in New York*
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Disclosure of carbon emissions and electricity use by miners is necessary for investors to assess climate risks, and for regulators and grid operators to understand the impact to energy systems, electricity infrastructure, and carbon reduction targets. Growing energy consumption by Bitcoin mining could prevent attainment of federal and state-level carbon reduction goals while straining electrical grids and increasing costs for ratepayers and taxpayers. Yet, the lack of accurate information from the Bitcoin mining industry about where facilities are located, where new ones are planned, and

[75] The Greenhouse Gas Protocol.2004. "A Corporate Accounting and Reporting Standard: The Revised Edition." https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf; The International Financial Reporting Standards Foundation. "SASB Standards - Overview." https://sasb.ifrs.org/standards/; International Financial Reporting Standards Foundation. "International Sustainability Standards Board Standards - IFRS S2 Climate-related Disclosures." https://www.ifrs.org/issued-standards/ifrs-sustainability-standards-navigator/ifrs-s2-climate-related-disclosures.html/content/dam/ifrs/publications/html-standards-issb/english/2023/issued/issbs2/#about

how much electricity is used and from what energy sources, makes it hard to plan and create appropriate policies.

In the U.S., which houses the most Bitcoin mining, the Energy Information Agency (EIA) needs to conduct regular surveys of Bitcoin mining companies' energy use and other pertinent details about their operations like facility locations, energy sources, and equipment. This information is necessary for tracking the industry's energy consumption, just like other industries, and creating standardized and reliable data. The EIA proposed an emergency survey of Bitcoin miners in January 2024 that was later rescinded in response to industry backlash and lawsuits.[76] The EIA should re-submit that survey to the Federal Register and open the proposal to the regular public input process. Further delay will hamper the ability of federal, state, and local officials to address this rapidly growing but secretive industry. This is vitally important given that U.S. electricity demand is projected to grow for the first time in a decade partially due to new load from data centers servicing Bitcoin mining and AI, with some estimates as much as 20% by 2030.[77] Data centers in the U.S. used more than 4% of total electricity in 2022 but, according to the International Energy Agency, by 2026 data center electricity demand could jump to 6% while global demand from the sector doubles, reaching the amount of electricity used by Japan.[78]

**Financial companies also need to report on the financed and facilitated emissions associated with their investments, loans, and underwriting services for Bitcoin mining companies.** The impact of these investments can no longer be invisible, and companies need to align their ties to Bitcoin with corporate climate commitments and sustainability goals. Individual and institutional investors need to know if their funds with companies like Vanguard, BlackRock, and State Street are tied to polluting and risky Bitcoin mining companies. And shareholders in banks, venture capital firms, insurers, and other financial services companies also need to be aware of the climate and financial risks from lending and investing in Bitcoin miners.

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[76] Kearney, Laila. February 23, 2024. "EIA to temporarily suspend bitcoin miner survey after lawsuit -court document." *Reuters*. https://www.reuters.com/technology/eia-temporarily-suspend-bitcoin-miner-survey-after-lawsuit-court-document-2024-02-23/

[77] Kimball, Spencer. May 5, 2024. "AI could drive a natural gas boom as power companies face surging electricity demand." *CNBC*. https://www.cnbc.com/2024/05/05/ai-could-drive-natural-gas-boom-as-utilities-face-surging-electric-demand.html

[78] International Energy Agency. May 2024. " Electricity 2024 - Analysis and forecast to 2026." https://iea.blob.core.windows.net/assets/18f3ed24-4b26-4c83-a3d2-8a1be51c8cc8/Electricity2024-Analysisandforecastto2026.pdf

*Banner at Coalition against Cryptomining Town Hall Meeting in Texas*
© Brittany Hallberg / Greenpeace

## Make Miners Pay Their Fair Share

**Ensuring Bitcoin miners pay a fair share for their electricity use, strain on electrical grids, greenhouse gas and other air pollution emissions, water consumption, and disruption to nearby communities is also a key step towards accountability.** Policies that make miners pay for the environmental, social, and economic costs of their operations would also create pressure to change how Bitcoin operates to eliminate the huge appetite for energy. Currently, many mining companies benefit from low electricity rates through fixed-rate contracts with utility companies, various local and state tax cuts and subsidies, and other programs that prop-up company profits.[79] Yet large Bitcoin mining facilities can drive up electricity prices for regular ratepayers, jeopardize carbon reduction goals and renewable energy portfolio standards, and bring hazardous noise, air, and water pollution to nearby residents. Bitcoin mines, and data centers more broadly, also provide limited economic development and job creation especially for the rural communities where mines are often located.[80] Research has found that small increases in local tax revenue from mining facilities are outweighed by higher energy prices for other companies and households.[81] Therefore,

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[79] Vu, Kevin, and Emily Foxhall. January 3, 2024. "Texan Bitcoin miners profit by using less electricity; advocates say all Texans should get the same chance." *Texas Tribune.* https://www.texastribune.org/2024/01/03/texas-bitcoin-profit-electricity/

[80]Samford, Heidi, and Lovely-Frances Domingo. July 10, 2019. "The Political Geography and Environmental Impacts of Cryptocurrency Mining." *The Henry M. Jackson School of International Studies, University of Washington.* https://jsis.washington.edu/news/the-political-geography-and-environmental-impacts-of-cryptocurrency-mining/#_ftn37

[81] Benetton, Matteo, Giovanni Compiani, and Adair Morse. June 2023. "When Cryptomining Comes to Town: High Electricity-Use Spillovers to the Local Economy." *National Bureau of Economic Research.* Working Paper 31312. https://www.nber.org/papers/w31312

reducing and eliminating various subsidies, like tax breaks and reduced electricity rates, for Bitcoin mining companies is necessary to make sure public funds aren't helping to sustain this polluting industry.

One potentially effective policy is placing taxes on the electricity use or carbon emissions of Bitcoin miners. U.S. President Joe Biden proposed a 30% excise tax on electricity used by cryptocurrency mining companies in both his 2024 and 2025 budget.[82] The Digital Asset Mining Energy (DAME) tax is an attempt to make miners pay for the costs imposed on communities and the environment, and could incentivize miners to clean-up their operations.[83] However, the DAME tax has not been included in any current federal legislation.

## Code Change to Eliminate Bitcoin's Proof-of-Work Pollution

**Changing Bitcoin's consensus mechanism to eliminate the current form of energy-guzzling PoW is the ultimate solution to Bitcoin's climate problem.** Disclosure, taxes, and fees are not long-term solutions, instead we need a fundamental change in the energy-intensive code that's driving Bitcoin's carbon emissions. A shift away from PoW toward a new, less energy-intensive system could slash Bitcoin's carbon and environmental footprint. Creating a new clean blockchain for Bitcoin can make it less risky and future-proof it for the impacts of climate change and energy transitions.

Bitcoin can, and has, changed, just like other cryptocurrencies. Ethereum, the second largest cryptocurrency in the word, got rid of its PoW consensus mechanism and transitioned to Proof of Stake (PoS), which cut its energy use by 99.95%.[84] Bitcoin's code is regularly being updated and it could be updated to meet the realities of the climate crisis. However, the social challenges of making this change are much bigger than the technical demands. Thus, large and small stakeholders within the Bitcoin community, particularly the companies funding large-scale mining operations, must champion solutions that protect the climate and communities.

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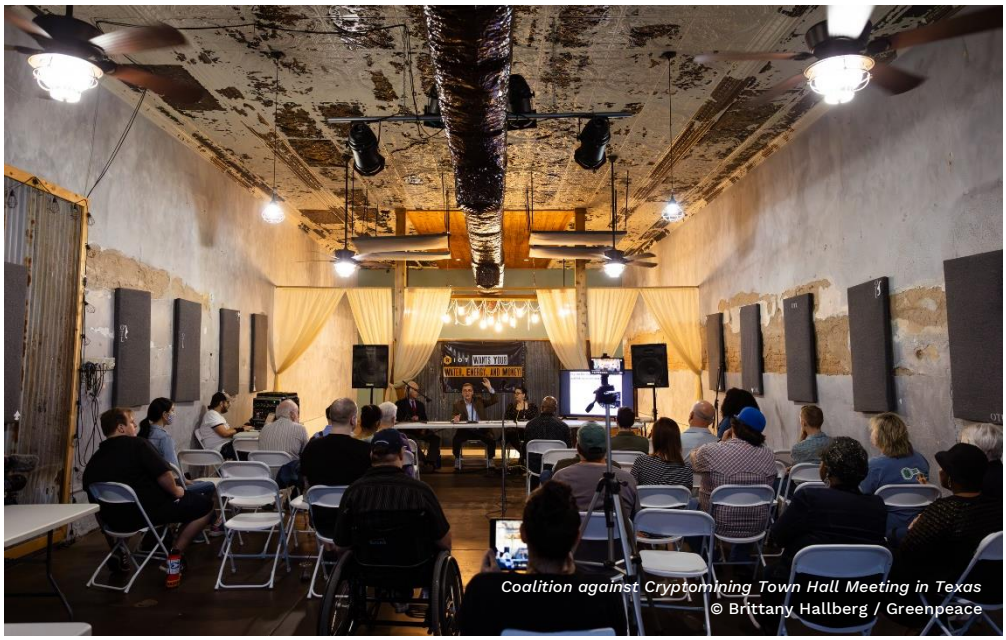
[82] Sparkes, Matthew. March 12, 2024. "US government wants to tax bitcoin to reduce its environmental impact." *New Scientist*. https://www.newscientist.com/article/2421745-us-government-wants-to-tax-bitcoin-to-reduce-its-environmental-impact/

[83] Council of Economic Advisors. May 2, 2023. "The DAME Tax: Making Cryptominers Pay for Costs They Impose on Others." U.S. Whitehouse. https://www.whitehouse.gov/cea/written-materials/2023/05/02/cost-of-cryptomining-dame-tax/

[84] de Vries, Alex. 2023. "Cryptocurrencies on the Road to Sustainability: Ethereum Paving the Way for Bitcoin." Patterns 4(1). https://doi.org/10.1016/j.patter.2022.100633.

The Bitcoin industry relies on misleading and unsubstantiated claims that mining can incentivize renewable energy or use stranded energy. Instead of relying on these speculative and unreliable assertions, the most effective approach is to modify Bitcoin's underlying code to operate without large energy requirements altogether. By replacing the energy-intensive PoW mechanism, Bitcoin stakeholders can start to align with global efforts to combat climate change by reducing its environmental impact and demonstrating a commitment to responsible innovation within the cryptocurrency sector.



*Coalition against Cryptomining Town Hall Meeting in Texas*
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# Appendix 1: Methods and Data

## Financial Research

Greenpeace staff collaborated with the independent research organization Profundo to detail financial relationships between financial institutions and Bitcoin mining companies, and the emissions that resulted. Research began with identifying 78 Bitcoin mining companies, which included both public and private ownership. Of the 78 companies originally scoped, only 29 had identifiable financial data on investments and credit with financial institutions. Throughout the report, we only considered the financial data from the 20 mining companies that had disclosed both financial data and sufficient information needed to estimate emissions.

We worked with Profundo to collect financial information on mining companies for the fiscal year 2022, the most recent full year we could get reliable data on company finances. Because we were interested in estimating financed and facilitated emissions, Profundo collected data on company shares and bonds that were issued and held in 2022, and loans and underwriting provided in 2022. Investor data (shares and bonds) were collected over two periods: shareholdings were captured for December 2022, and bond holdings were retrieved for the latest available period due to lack of historical bond holdings data, in December 2023. Since bond holdings tend to be long-term, we assumed this would adequately reflect bond holdings for the 2022 fiscal year. Creditor data (loans and underwriting services) were considered between January 2012 and December 2022 under the assumption that most financing through loans matures within ten years, and because the industry of Bitcoin mining is quite young. We only discovered financing between 2019 and 2022.

Financial databases were used to collect a large amount of financial information on mining companies, especially Refinitiv and Bloomberg for investment data (share and bond holdings) and loans. IJGlobal as well as company annual reports, financial statements, company registries, and media archives were also employed to detail additional financial information such as bilateral financing. Generally, syndicated lending was more consistently reported than bilateral financing, and there may be additional bilateral lending that was not accounted for in our research. Some investments were also more opaque, particularly for financial institutions like insurance companies and pension funds that do not have the same requirements for publishing investment portfolios or do not offer asset

management activities. Profundo was able to provide data from their database of pension fund portfolio disclosures.

## Estimating Emissions by Mining Companies

Greenpeace staff collected information about each mining company identified by Profundo in order to facilitate estimates and research conducted with WattTime, an independent research nonprofit. Although we were able to find financial data on 29 mining companies, only 20 also had sufficient information on mining operations to estimate emissions. We collected information on the mining facilities that were operating by each mining company in 2022, including the facility location, mining equipment, hashrate, power capacity, and details about agreements with energy suppliers such as energy source and licensed energy allotment. Of the 20 mining companies we investigated in this report, there were 84 operating facilities. The most important data for estimating emissions was the amount of Bitcoin mined, the location of each facility, the power capacity of the facility, and the energy supply. This information was gathered through public company filings and occasionally on company websites. This report details the 20 mining companies for which this data was available to make reasonable emissions estimates in conjunction with financial information.

WattTime geocoded the location of each facility to approximate spatial coordinates of each mine. These coordinates were then associated with a specific grid region, based on WattTime's grid region data, which provided location-specific information about available energy sources. For a small number of mines, we could only confirm location to a province- or state-level instead of a city. In these cases, a region was manually selected based on province or state information.

The actual energy usage (in MWh) by a mining facility was also not reported in company filings. In conjunction with Profundo and WattTime, emission estimates were informed by the estimated electricity consumption per Bitcoin and the number of Bitcoin each company reported mining in 2022. The number of Bitcoin mined per company was split amongst each facility proportional to the power capacity of each facility. The estimated electricity consumption per Bitcoin was informed by the Cambridge Bitcoin Electricity Consumption Index for 2022 (CBECI).[85] CBECI estimates include a "best

[85] The daily power consumption per bitcoin in 2022 was 288.44 MWh in the "best guess" scenario, with lower and upper bounds of 149.52 and 672.49 MWh, respectively. Cambridge Centre for Alternative

guess" scenario as well as upper and lower bounds based on variation in miner efficiency, energy source, and other factors. Therefore, the annual electricity consumption by each mining company was informed by the number of Bitcoin mined by a company, the CBECI estimate for electricity consumed to mine a Bitcoin, and the relative power capacity of each facility. We calculated emissions using all three of these scenarios to better inform a range of possible emissions values (see Appendix 2 Figure A5 for emissions range estimates).

For some mining facilities, some key information was not available in public company filings or other official records. When power capacity for a facility was not available, either the equipment amount and type used for mining or the facility hashrate were used to inform estimates of energy use and emissions. We often found that mining companies publicly self-described their operations as "carbon-free" or using clean or renewable energy did not provide any specific evidence of this in the company filings. Some companies did report purchasing RECs and other carbon offsets. We assumed that each mining facility was operating on the local grid in the absence of any legitimate evidence of another energy source (e.g. power agreements or deals with renewable energy suppliers, or evidence of operating clean energy production facilities). We did not account for purchasing RECs or other carbon offsetting activities—so-called "market-based emissions"—and instead calculated location and consequential emissions by mining companies that exclude any offsets.

Additionally, our methodology and data did not account for companies hosting mining for third-parties and any Bitcoin that were minted on behalf of another company. This is primarily a result of lack of reporting by mining companies about what third-party contracts they maintain, either to provide or use additional mining services. Thus, we are not able to capture the electricity and carbon emissions generated from hosting mining services which for some Bitcoin mining companies can be quite large. Due to the lack of disclosures about companies using third-parties to host mining capacity, we are not able to assess the emissions generated by Bitcoin minted at facilities that are not owned and operated by the company. Thus, emissions calculations are based on assuming all Bitcoin were mined at the company's own facilities.

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Finance at the Judge Business School, University of Cambridge. "The Cambridge Bitcoin Electricity Consumption Index (CBECI) Methodology." https://ccaf.io/cbnsi/cbeci/methodology

WattTime determined the mean operating marginal emissions rate[86] and average (location-based) emissions rate[87] for 2022 for the grid region where each mine was located. The consequential emissions were calculated by multiplying the annual electricity consumption by the marginal operating emissions rate. The attributional, location-based emissions were calculated by multiplying the annual electricity consumption by the average emissions rate. This calculation was done using the best guess, upper bound, and lower bound scenario for electricity use per Bitcoin mined from CBECI. Emissions values used for graphs and tables were rounded to the nearest thousand metric tons $CO_2$.

## Assigning Financial and Facilitated Emissions

We consider both financed and facilitated emissions associated with financial institutions' activities with Bitcoin mining companies. Facilitated emissions and financed emissions are two distinct ways of accounting for the GHG emissions tied to financial relationships. Using emissions estimates from WattTime, Profundo carried out the calculation of financed and facilitated emissions using the Partnership Carbon Accounting Financials (PCAF) methodology developed by financial institutions to measure and report financed emissions.[88]

The GHG emissions generated by the mining operations that a financial institution directly lends money to or invests in through loans or share or bond holdings are referred to as financed emissions.[89] These emissions are directly linked to the financial institution's lending and investment activities on its balance sheet. Commercial and investment banks are the main entities providing corporate loans while asset managers own shares and bonds as part of their investment portfolios.

Facilitated emissions are GHG emissions associated with financial activities that enable companies to generate emissions.[90] These financial activities can include insurance services, providing access to capital markets by

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[86] WattTime. "Signal: Marginal $CO_2$." https://watttime.org/data-science/data-signals/marginal-co2/; Siler-Evans, Kyle, Inês Lima Azevedo, and M. Granger Morgan. 2012. "Marginal Emissions Factors for the U.S. Electricity System." *Environmental Science & Technology* 46 (9), 4742-4748. ttps://pubs.acs.org/doi/10.1021/es300145v

[87] WattTime. "Signal: Average $CO_2$." https://watttime.org/data-science/data-signals/average-co2/

[88] PCAF Standards for GHG calculation and reporting include industry-supported methods for accounting for financed and facilitated emissions, as well as insurance-assisted emissions which we do not explore.

[89] PCAF. 2022. *The Global GHG Accounting and Reporting - Standard Part A: Financed Emissions*. Second Edition. https://carbonaccountingfinancials.com/files/downloads/PCAF-Global-GHG-Standard.pdf

[90] PCAF. 2023.*The Global GHG Accounting and Reporting - Standard Part B: Facilitated Emissions.* https://carbonaccountingfinancials.com/files/PCAF-PartB-Facilitated-Emissions-Standard-Dec2023.pdf

underwriting bonds or share offerings, or other financial services that facilitate a company's operations (and emissions), without direct lending or investment.[91] Investment banks are the major players in underwriting and helping companies access capital by selling newly issued shares and bonds. Underwriters also have deep insights into company operations and finances since they do research to assess the value of the company and accurately price shares and bonds. Thus, they should also be aware of the company's energy use and emissions.

In the context of Bitcoin mines, financed emissions are the emissions caused by mines that a financial institution has provided loans to or invested in through shares and bonds. Facilitated emissions could include emissions from mines that the financial institution has enabled through financial support like underwriting an Initial Public Offering (IPO) or issuing a new bond without directly financing the mining operations through loans or investments.[92] Both financed and facilitated emissions are calculated using attribution factors that reflect the amount of investments or credit provided by a financial institution as well as the enterprise value based on market capitalization or market capitalization plus total borrowings plus minority interest.[93] The latter information was retrieved from the financial database Refinitiv.

[91] *ibid*
[92] PCAF. 2023.*The Global GHG Accounting and Reporting - Standard Part B: Facilitated Emissions.* https://carbonaccountingfinancials.com/files/PCAF-PartB-Facilitated-Emissions-Standard-Dec2023.pdf
[93] *ibid*

# Appendix 2: Additional Figures, Data, and Estimates

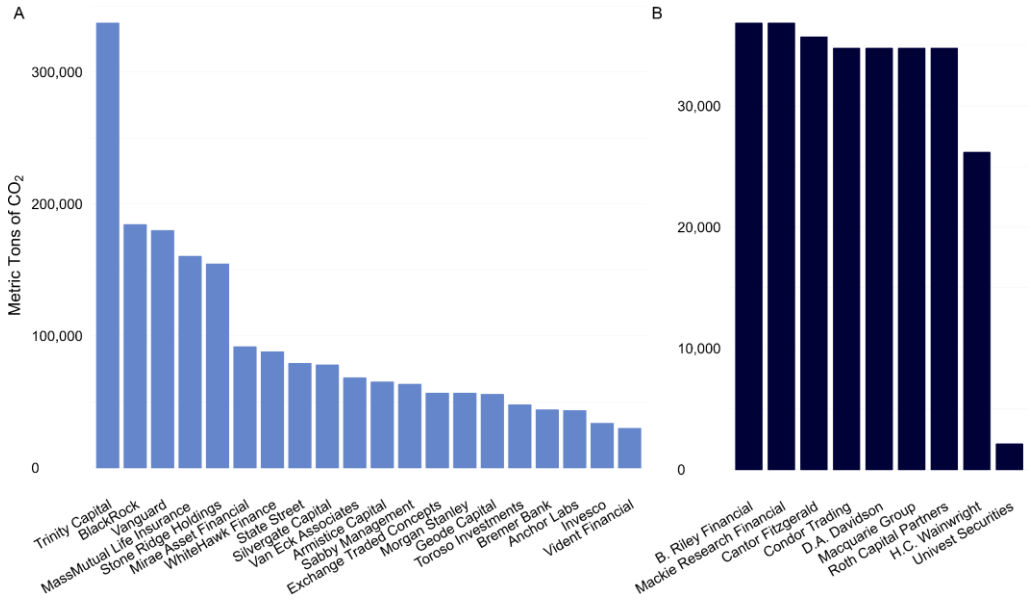


Figure A1. The largest financed (A) and facilitated (B) attributional emissions by financial institutions based on identified investments and lending to Bitcoin mines in 2022.

| Financial Company | Financed Emissions (metric tons $CO_2$) |
|---|---|
| Trinity Capital | 337,000 |
| BlackRock | 184,000 |
| Vanguard | 180,000 |
| MassMutual | 160,000 |
| Stone Ridge Holdings | 154,000 |
| Mirae Asset Financial | 91,000 |
| WhiteHawk Finance | 88,000 |
| State Street | 79,000 |
| Silvergate Capital | 78,000 |
| Van Eck Associates | 68,000 |
| Armistice Capital | 65,000 |
| Sabby Management | 63,000 |
| Exchange Traded Concepts | 56,000 |
| Morgan Stanley | 56,000 |
| Geode Capital Holdings | 55,000 |
| Toroso Investments | 48,000 |
| Bremer Bank | 44,000 |
| Anchor Labs | 43,000 |
| Invesco | 34,000 |
| Vident Financial | 30,000 |
| **Total** | **1,913,000** |

| Financial Company | Facilitated Emissions (metric tons $CO_2$) |
|---|---|
| B. Riley Financial | 37,000 |
| Mackie Research Financial | 37,000 |
| Cantor Fitzgerald | 36,000 |
| Condor Trading | 35,000 |
| D.A. Davidson | 35,000 |
| Macquarie Group | 35,000 |
| Roth Capital Partners | 35,000 |
| H.C. Wainwright | 26,000 |
| Univest Securities | 2,000 |
| **Total** | **278,000** |

Table A1 The largest financed and facilitated attributional emissions by financial companies with identified investments or credit in Bitcoin mines, respectively.

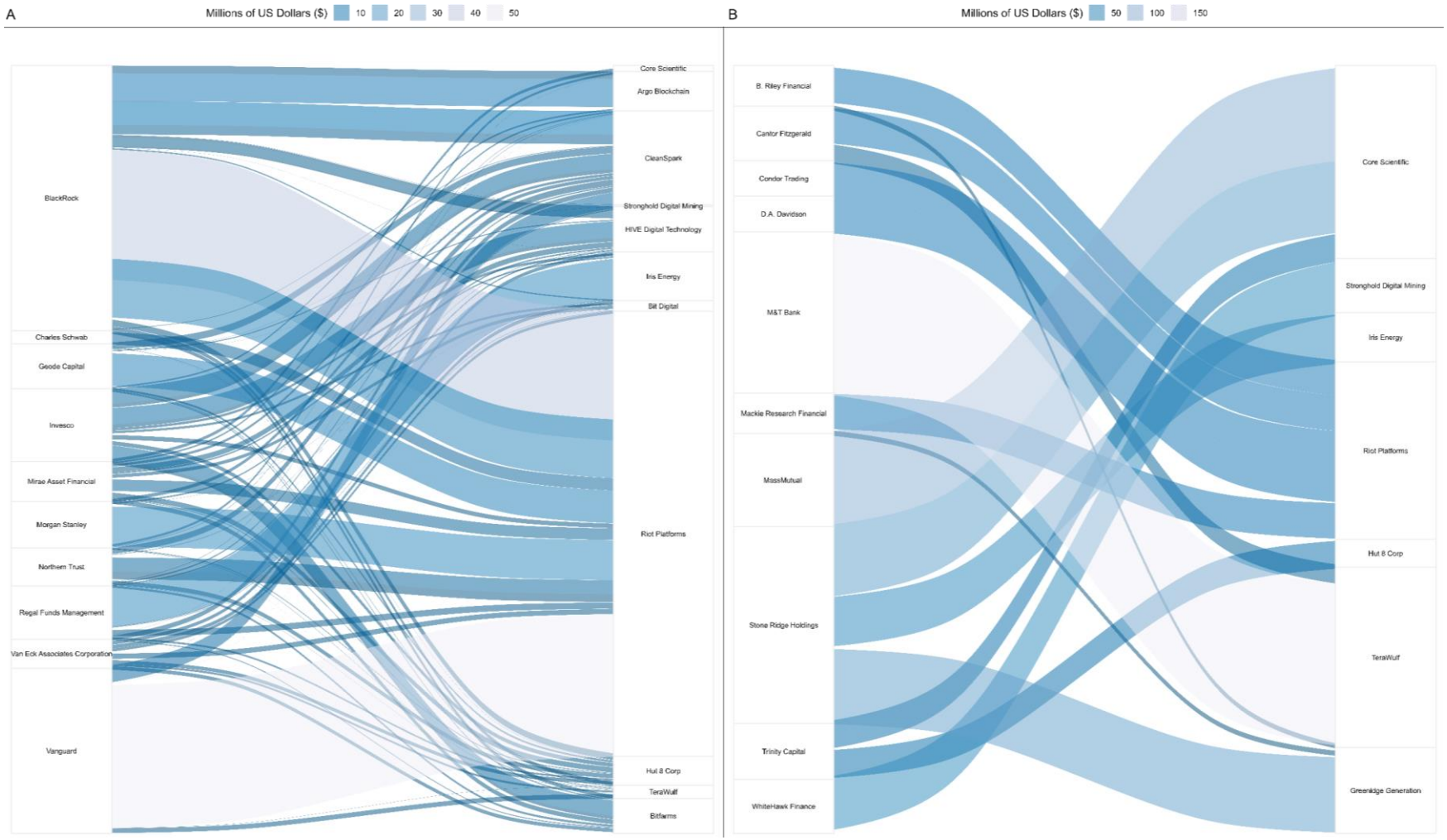


Figure A2. Comparing the flow of investment dollars (A) and lending and underwriting (B) from financiers into focal Bitcoin mining companies shows variation in the amount of money each miner received, and the diversity of financial institutions' identified investments and credit to the industry. The thickness of each flow is proportional to the amount of money invested or credited to a mining company, and the approximate value is shown by the color of each flow in millions of US dollars. Major banks and firms provided significant financing in 2022, with Marathon Digital and Riot Platforms receiving the largest investments and Marathon Digital and Core Scientific receiving the most lending and underwriting, while other miners secured smaller but still substantial funding from both investors and lenders and underwriters.


Figure A3. (A) Attributional emissions estimated for focal Bitcoin mining companies for the fiscal year 2022. Emissions calculations were done by WattTime with support from Profundo and Greenpeace. (B) The carbon intensity of mining operations was estimated as the attributional emissions per Bitcoin mined by each miner in 2022.

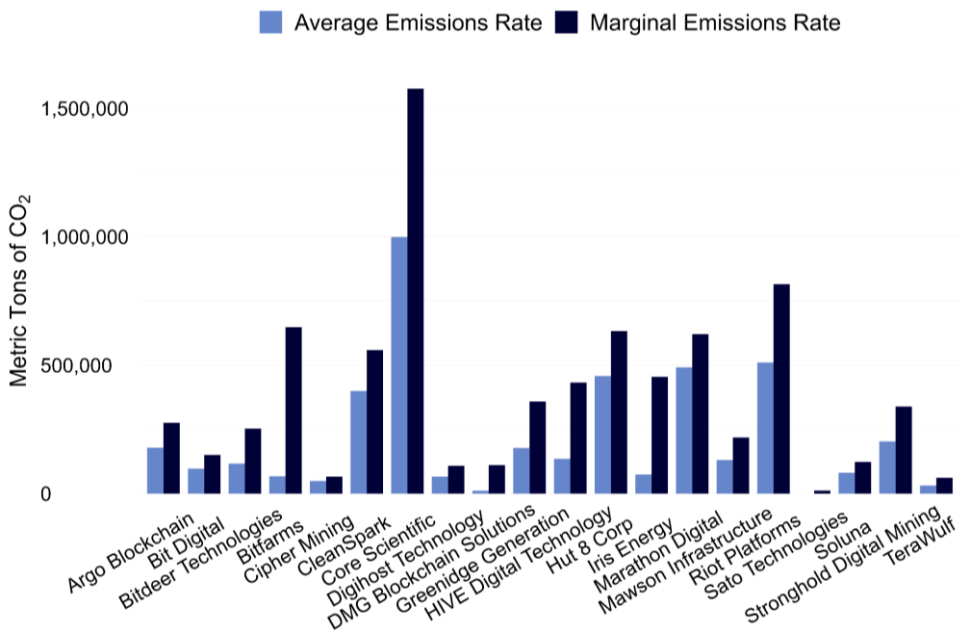


Figure A4. Consequential and attributional emissions estimated using marginal and average, location-based emissions rates for focal Bitcoin mining companies for the fiscal year 2022. Emissions calculations were done by WattTime with support from Profundo and Greenpeace. Consequential emissions calculated with a marginal emissions rate were consistently higher than attributional emissions, which used an average emissions rate.

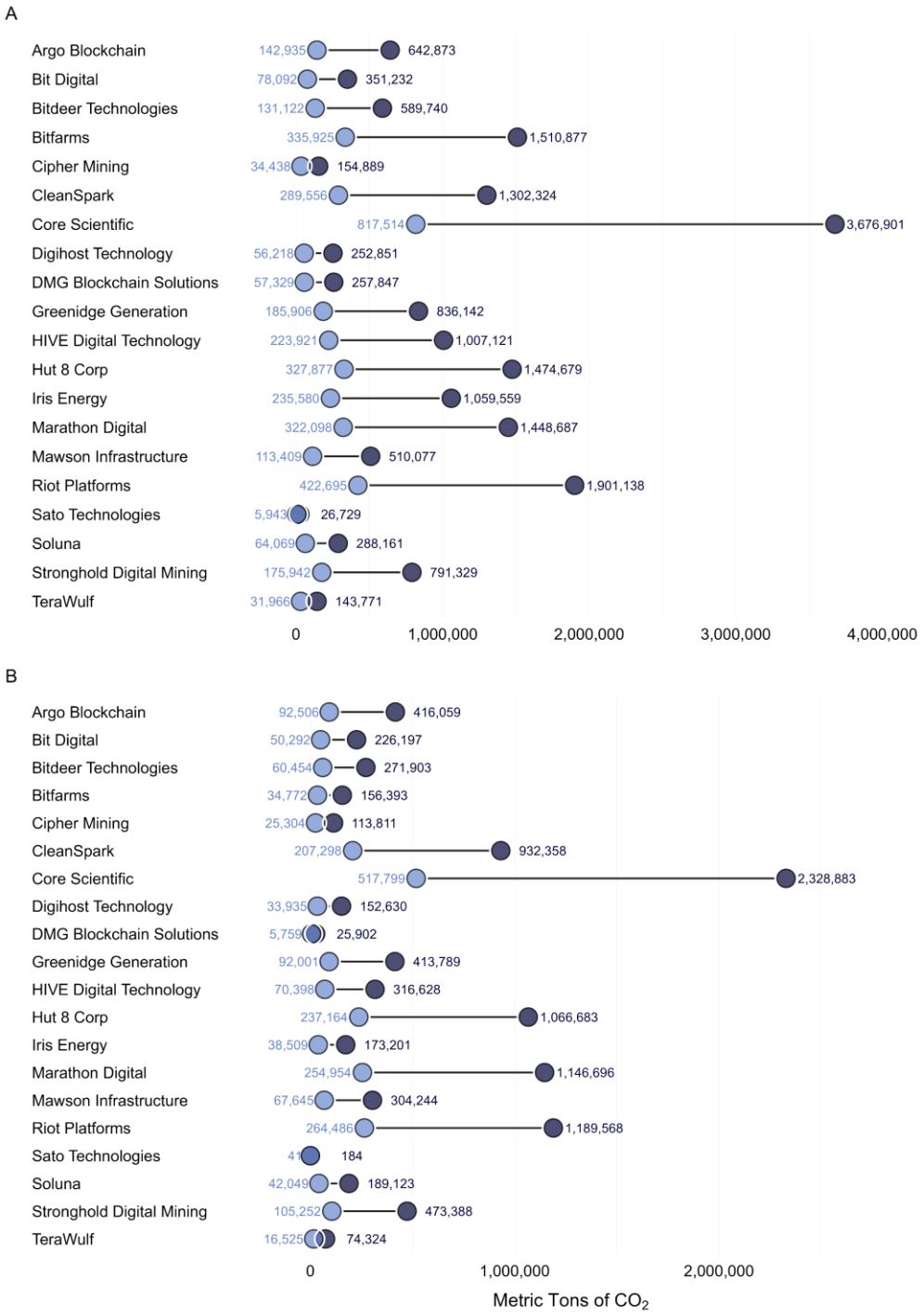


Figure A5. Consequential emissions estimates were informed by the CBECI approximation for how much electricity is consumed to mine a single Bitcoin. The CBECI calculation accounts for a “best guess” scenario, as well as an upper and lower bound. Throughout this report we focus on the emissions estimates from the best guess scenario, but here we highlight the range of emissions estimates depending on the upper and lower bound of the CBECI electricity consumption for mining. Using the upper and lower bounds led to the following range of possible (A) consequential and (B) emissions estimates for Bitcoin miners.

*Activists Bring "Skull of Satoshi" to Fidelity's Offices in New York City*
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