HEARING BEFORE THE UNITED STATES SENATE
CLEAN AIR, CLIMATE, AND NUCLEAR SAFETY SUBCOMMITTEE
ON THE CRYPTO-ASSET ENVIRONMENTAL TRANSPARENCY ACT

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Thank you, Chairman Markey, Ranking Member Ricketts, and members of the committee, for the opportunity to testify today in support of the Crypto-Asset Environmental Transparency Act. My name is Robert Altenburg, and I am the Senior Director for Energy and Climate at Citizens for Pennsylvania's Future (PennFuture). We are a nonprofit environmental advocacy organization with offices across Pennsylvania that is committed to leading the transition to a clean energy economy in Pennsylvania and beyond.

I've worked at PennFuture since 2014 and, before that, spent nearly 22 years at the Pennsylvania Department of Environmental Protection working in both the Bureau of Air Quality and the Policy Office on a wide range of issues impacting air pollution and energy. In the last few years, I've been following the growth of Bitcoin and other proof-of-work cryptocurrency operations with significant concern.

I.   Introduction:

What is proof-of-work mining, and why it is a problem?

Bitcoin[1], and blockchain technology in general, is based on a very simple mathematical tool called a "hash". In practice, this is just a bit of computer code that, given any data, returns a number that represents a unique digital fingerprint.[2] While this hash helps keep the system secure, Bitcoin's implementation requires an enormous number of unnecessary hash calculations and that ultimately wastes energy.

Using a tool like a hash to fingerprint pages of a financial ledger, or similar data, can make it more difficult for someone to alter records, but only if copies of the fingerprints are kept somewhere secure, otherwise, a bad actor could alter the copies of the fingerprints too. Rather than rely on trusted third parties, like the government or a corporation, to keep everything secure, blockchains solve this problem by having each page of the ledger, or "block" of data, contain the fingerprint of the prior page. To change one piece of data on such a blockchain, the bad actor would need to change all the subsequent blocks. The harder that is to do, the more resistant the data is to manipulation.

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[1] S. Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System, (2008) (*available at: https://www.bitcoin.com/satoshi-archive/whitepaper/*)

[2] Specifically, SHA-256, defined *at: Nat't. Inst. of Standards and Technology, FIPS PUB 202 (Aug 2015) (available at: http://dx.doi.org/10.6028/NIST.FIPS.202).*

Each blockchain sets its own rules, or "consensus mechanism", that allows everyone to validate and agree when new blocks are added. Because new Bitcoins are created every time a block is added to its blockchain, the consensus mechanism also must be rate-limited to avoid hyper-inflation that would devalue the cryptocurrency. To accomplish this, Bitcoin's creator chose to use a very simple consensus mechanism that is now called "proof-of-work".

Essentially, prospective Bitcoin miners[3] combine proposed transactions they want to include in with the hash (fingerprint) of the prior block, and some assorted boilerplate information, into a new potential block and calculate its hash. For this new block to be valid and accepted by the rest of the network, that hash must be a low-enough number. Exactly how low depends on how many other people are trying to create blocks—the system changes this target hash periodically adjust its difficulty and ensure new blocks are generated roughly every ten minutes no matter how much computer power is used to mine. Right now, the odds of any one prospective block being valid are less than one chance in a hundred billion trillion. If the potential block is no good, the miner must start the process again.

To improve their odds, miners need to test as many potential blocks as possible, but this is also a race. The first miner to find a valid block currently is rewarded with 6.25 new Bitcoin, worth around $145,000, plus any transaction fees. All the other miners get nothing for their effort and start again from scratch to find the next block.

Because the chances of finding a valid block are incredibly low and the stakes are high, miners buy special-purpose computers called Application Specific Integrated Circuits (ASICS) that can each calculate around a hundred trillion of these hashes every second. But, in the process, they use a lot of energy. A single ASIC these days uses around three times as much electricity as an average household, and a single mining operation may use tens-of-thousands of these devices in massive racks.

Combined, the entire Bitcoin mining network uses over a hundred trillion watt-hours each year[4]. That is more electricity than we consume in about 80 percent of our states, and more than many entire countries.

For Bitcoin, wasting this much energy is part of the design, but it's just not necessary. We can think of proof-of-work as "Version 1.0" and, like many products, newer innovations have been developed to accomplish the same things faster and cheaper.

In this case, non-proof-of-work blockchain systems have been successfully operating for over ten years[5] and, in many cases, these alternate systems offer more capabilities than the Bitcoin blockchain while having a tiny fraction of the energy demand.

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[3] Calling the process of creating new Bitcoins "mining" and the creators "miners" is based on an analogy to gold mining (*See:* S. Nakamoto, at 4.)

[4] Cambridge Bitcoin Energy Consumption Index (*available at: https://ccaf.io/cbeci/index).*

[5] Peercoin implemented a proof-of-stake system in 2012.

II.   Bitcoin Mining is Causing Increased Pollution

With no specific reporting requirements and inconsistent permitting, we often rely on media reports, or reports from residents, to discover new Bitcoin mining operations. What we have seen, however, represents a disturbing trend.

Waste coal

In July of 2021 a company by the name of Stronghold Digital Mining (Stronghold) filed an S-1 report with the Securities and Exchange Commission (SEC) disclosing plans to purchase three waste coal fired power plants and install 57,000 Application Specific Integrated Circuits (ASICs) dedicated to mining bitcoin. To date, Stronghold has purchased the 94-megawatt (MW) circulating fluidized bed (CFB) Scrubgrass power plant in Venango County and the 94 MW Panther Creek CFB facility in Carbon County. Strongholds initial plans also contemplated the purchase a third facility bringing their total generating capacity to 300MW.[6] As of March 24, 2022, the company operated approximately 20,500 pieces of mining hardware and purchase agreements in place for an additional 29,400 miners.

Waste coal is a low-energy-value product that, before environmental restrictions were passed, was often dumped in piles near mining sites. Pennsylvania has approximately 840 such sites and operators such as Stronghold claim that burning it for energy is environmentally beneficial because it encourages the removal of these piles, and the waste ash can be used for fill and reclamation projects. Despite these claims, burning waste coal is still just burning fossil fuel and results in the emissions of significant amounts of air pollution including ozone precursors, fine particulates, acid gasses, heavy metals, and vast amounts of carbon pollution. The impacts of increased air pollution should not be ignored—particularly at these sites, since the Scrubgrass plant is located within ten miles of a designated Environmental Justice area and the Panther Creek plant is within three miles of such an area.

Burning a low-energy-value fuel source also requires subsidies to be profitable and the Pennsylvania state legislature has provided significant incentives to burn polluting waste coal. These incentives include $4/MWh from the Coal Refuse Reclamation tax credit and a claimed $16/MWh from the Tier II Alternative Energy Portfolio Standard Program. Altogether, Stronghold has claimed 60 percent of their generation costs will be covered by subsidies from taxpayers and ratepayers.[7]

Burning waste coal to generate electricity for bitcoin mining is one of the worst choices available. According to EIA data[8], Pennsylvania's waste-coal fired power plants had average CO2 emissions of over 2,760 pounds per megawatt-hour making them the second most carbon-intensive fuel behind residual fuel oil. This effect is compounded because facilities used to mine Bitcoin are operating at significantly higher capacity factors than plants suppling energy to the grid and Pennsylvania has nine other such facilities where mining could expand. There are better, safer, and in many cases cheaper ways to clean up waste coal than burning it for Bitcoin mining.

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[6] Stronghold Digital Mining, SEC Form 10-k, (filed Mar. 29, 2022).
[7] Stronghold Digital Mining, SEC Form S-1, (filed Jul. 27, 2021).
[8] US EIA, Emissions by Plant and Region, 2020 (*available at: https://www.eia.gov/electricity/data/emissions/*)

For example, in some cases waste piles have been stabilized by planting American beachgrass.[9] In other cases, it may be a better option to remove the material and dispose of it in an appropriately permitted facility.

Fracked gas

Pennsylvania is already seeing methane gas fired generators being installed directly at fracked gas well sites and, in certain market conditions these facilities could see significantly more revenue that would be obtained selling the gas on the wholesale market. Assuming no action by regulators, this would be expected to raise wholesale prices for methane gas which we currently rely on for 53% of their electricity generation and a significant portion of home heating. In addition to the consumer impacts, methane is 86 times more potent a greenhouse gas than carbon dioxide over a 20-year period, so any leakage from these operations would also be particularly dangerous for our climate.

In January of 2022, inspectors from the Pennsylvania Department of Environmental Protection (DEP) found 30 methane-gas-fired generators with an estimated capacity of more than 10MW at the Hegarty A well operated by Big Dog Energy, LLC and located in Clearfield County, PA within two miles of a designated Environmental Justice area. These generators were installed without authorization from the DEP in violation of Pennsylvania regulations and the resulting energy was being used to mine bitcoin.

While the DEP issued a Notice of Violation (NOV) for this operation[10], it is unknown how many of Pennsylvania's many thousands of methane gas wells–many in rural and low-income areas– are hosting similar mining projects. Big Dog Energy alone has 38 other active well permits across Pennsylvania.[11]

In addition to Big Dog Energy, another company, Pin Oak Energy, has purchased a midstream gathering system capable of 25,000 MMBtu/day. Given available ASIC mining hardware, that could represent fifteen to twenty thousand miners, and again, there are questions as to whether the required air quality permits have been obtained.[12]

Finally, in late 2022, Diversified Production LLC applied for an air quality plan approval to install five methane-gas fired generators to support bitcoin mining operation in Elk County, PA.[13] This site is particularly problematic as it is in a region known as the Pennsylvania Wilds— a rural area that heavily depends on nature tourism, and the impacts of the noise from this facility on wildlife has not, to our knowledge, been considered.

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[9] R. Glennon, S. DePue, Succession on a Coal Mine Gob Pile Stabilized with 'Cape' American Beachgrass (*available at: http://www.energyjustice.net/coal/wastecoal/beachgrass*)
[10] PA DEP, Notice of Violation to Big Dog Energy, LLC., (Jan. 7, 2022).
[11] PA DEP, eFacts information system (*available at: https://www.ahs.dep.pa.gov/eFACTSWeb/default.aspx/default.aspx*)
[12] B. Stockman, PA DEP Looking into Pin Oak Bitcoin Mine in Ridgeway Township, Ridgeway Record (Mar. 21, 2022) (*available at: https://www.ridgwayrecord.com/news/pa-dep-looking-into-pin-oak-bitcoin-mine-in-ridgway-township/article_5713036c-b136-11ec-bb37-2f666479782b.html*).
[13] Plan Approval Application 24-00195A, 52 Pa.B. 7143 (Nov 19, 2022).

Nuclear

In August of 2021, Talen Energy Corp. announced a joint venture with TeraWulf Inc. that would result in the construction of the 180MW Nautilus Cryptomine bitcoin mining facility adjacent to the Susquehanna nuclear power generating station in Columbia County, Pennsylvania.[14] It has since been reported that this facility will benefit from significant state subsidies in the form of Pennsylvania's datacenter tax exemption.[15]

While claims are made that this will use carbon-free nuclear generation, we reject any suggestion that this is environmentally neutral. In 2020, nuclear generation was responsible for more than 33 percent of Pennsylvania's energy generation and represented more than 92 percent of the carbon free energy generated. Diverting carbon free energy to wasteful Bitcoin mining virtually guarantees that demand will be backfilled with fossil resources.

Given Pennsylvania's grid mix, diverting 180MW of carbon free generation from the grid could result in over one million tons of additional carbon pollution per year, in addition to thousands of tons of NOx and other dangerous air pollutants.

III.   Wasting Energy on Proof-of-Work Mining Causes Additional Problems

Bitcoin mining operations are likely to raise wholesale electricity prices.

While most of the large Bitcoin mining operations in Pennsylvania are operating "behind the meter" and not drawing power from the wholesale power grid, there are still potential impacts for energy prices and reliability.

To the extent that miners are using electricity that would otherwise flow to the grid, that energy would, by definition, have been priced below PJM's market clearing price. By diverting that energy into wasteful Bitcoin mining, the energy markets will clear at a higher price. These increases in wholesale prices may ultimately be absorbed by consumers.

The claim that miners could provide a service to the grid as a source of interruptible load is highly suspect. Given current Bitcoin prices and network conditions, miners using competitive hardware can gross more than $100 per MWh.[16] According to PJM's Market Monitor[17], average monthly wholesale prices in 2021 never exceeded $92/MWh and averaged considerably less. That suggests that there are limited situations where miners would voluntarily curtail their demand because of price concerns. On the contrary, this makes it very likely that Bitcoin mining operations could be the marginal demand that sets an elevated price for the rest of the grid.

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[14] Press Release, *Talen Energy Corp. announces Bitcoin Mining Joint Venture with TeraWulf Inc.* (Aug. 3, 2021)

[15] Caruso, S., *Pa. passed a tax break for data centers. Now crypto-miners are taking advantage*, Penn-Capital Star, (Mar. 13, 2022).

[16] See Miner hardware profitability calculations at *https://minerstat.com/coin/BTC/profitability.*

[17] Monitoring Analytics, Components of PJM Price, 2021, (April 12, 2022) (*available at: https://www.monitoringanalytics.com/data/pjm_price.shtml).*

Bitcoin mining does not help clean energy.

A similar strawman argument is to claim that mining Bitcoin could "absorb wasted clean energy." Again, this assumes that the only option is waste and Bitcoin mining is a viable alternative—neither is likely true.

In certain scenarios, energy markets have shown a "duck curve" where high solar generation has driven prices very low—sometimes even negative—for short periods in the mid-day period before ramping up sharply later in the day. This can be addressed in different ways, including increased investment in transmission allowing power to be wheeled to where there is demand, and increased storage allowing the excess energy to be used later.

It's unlikely Bitcoin will do anything to alleviate this issue. First, one of the reasons Bitcoin miners gravitate to more expensive fossil fuels rather than clean renewable generation is because 24/7 operations at high-capacity factors is more profitable. This is driven both by the nature of proof-of-work mining pools where increased hash rates directly translate to increased profits. (Other factors include the relatively short competitive life of ASIC hardware and the extreme market volatility.) It is highly unlikely that miners will invest a significant amount of money in mining hardware and let it sit idle until the energy grid "needs" their load.

It's far more likely that these mining operations will burn fossil fuels for energy to support their 24/7 operations and only curtail that generation and buy from the grid when price signals favor doing so. While there may be rare cases when this might keep grid prices from going negative, that will come at a significant cost. In normal operation, the marginal cost of the Bitcoin miner's behind-the-meter generation will become a floor price for the market and have the effect of raising average wholesale prices for everyone while continuing polluting combustion.

Bitcoin mining isn't a solution to the problem of flared methane gas.

A recent claim noted that using methane gas for mining Bitcoin is a "better" choice than flaring it, but that is yet another strawman argument. An even better choice is investing in energy efficiency, electrification, and clean renewable generation, so we avoid the emissions and risk associated with extracting the fossil fuels in the first place.

The next logical question is why is there such an excess of flared gas? The 2016 New Source Performance Standards (NSPS)[18] for oil and gas require that many wells utilize reduced emissions completions where gas is either captured and used for some productive purpose or reinjected. Those same standards will also often require low-bleed pneumatic controllers or other technology that further reduces the amount of potentially vented gas. Where flaring is allowed, this tends to be for a limited time and only for a limited number of wells.

Before claiming proof-of-work mining is a solution, we should first be sure the problem is well understood. Using flared methane gas for Bitcoin presupposes that capture of the gas be technically feasible and that enough gas is available that it is economical to use. Assuming that is the case, the question then is why is it not already being captured? The implication is that

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[18] *See:* 40 CFR 60.5360 *et seq.* (*published:* 81 Fed. Reg. 35824 (Jun. 3, 2016))

regulators are allowing oil and gas operators to opt-out capturing the gas for financial reasons. Such exemption forces the citizens to absorb the risk and damage from the polluting industry and acts as a subsidy encouraging pollution. If polluting industries were, instead, required to internalize the costs of their waste, flaring would be less of a problem.

Proof-of-work cryptomining hardware is not energy efficient.

Bitcoin advocates have also attempted to distract from criticism of Bitcoin's enormous energy demand with red herring arguments. One example raised at a 2022 Congressional hearing[19] was the claim that because the ASICs used for mining are highly optimized for hashing blocks of data, they are more efficient—or less energy intensive—than general-purpose computers used in conventional datacenters.

While an ASIC may be the least energy intensive tool available to calculate more than 100 trillion hashes in one second, that cannot be considered an efficient process if an alternate methodology exists that avoids the need to calculate trillions of hashes in the first place. In much the same way, using a single enormous mining truck may be the best way to move 400 tons of dirt, but if the desired results don't require moving dirt at all, the efficiency of the truck is irrelevant.

We also note that ASIC hardware has an extremely limited useful life before it becomes obsolete e-waste. Hardware that was introduced just two or three years ago is often impossible to operate profitably and even newer hardware may be replaced and discarded in favor of the latest and most competitive equipment.

At a time when semiconductor shortages are contributing to higher consumer prices, this wasteful hardware cycle to proliferate is a particularly bad policy choice that disproportionately impacts low- and moderate-income families.

IV.   Conclusion and Policy Recommendations

Reporting and quantifying the problem is essential.

In our discussions with regulators, we often find that they are unable to say with any degree of confidence where proof-of-work mining is happening. Even where permit-applications or local media stories indicate a project is being developed, it may be reported as a "datacenter" or other generic term not associated with crypto-mining. In this regard, the reporting provisions in Senator Markey's Crypto-Asset Environmental Transparency Act are an essential step.

We should use the best available technology to reduce pollution and protect public health.

State and federal laws to combat air pollution often incorporate the principle that, before an industrial source is allowed to dump its waste into our air, it first must ensure it's using the best

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[19] U.S. House Committee on Energy and Commerce Hearing, Cleaning Up Cryptocurrency: The Energy Impacts of Bitcoin, (Jan. 20, 2022).

technology available to reduce its emissions. Blockchain technology and crypto-currencies should be no exception and cleaner alternatives than proof-of-work mining are available.

Noise pollution must be systematically addressed.

In establishing a federal noise abatement program in the early 1970's, the EPA stated that "Noise differs from most other environmental pollutants in one very important aspect—the knowledge and technology exists now to control almost every indoor and outdoor noise problem"[20] In spite of this, one of the chief areas of concern we hear regarding crypto-mining is the loud and ceaseless noise created by these operations.[21] Relying on local governments and public nuisance claims has not been effective to stop these operations—particularly in rural areas where the impact may be most acute on wildlife.

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[20] U.S. EPA, EPA's Noise Abatement Program (May 19, 1971).
[21] Vipal Monga, Bitcoin Mining Noise Drives Neighbors Nuts, Wall Street Journal, (Nov. 12, 2021).