COMMITTEE ON
ENERGY & COMMERCE
CHAIRMAN FRANK PALLONE, JR.

MEMORANDUM

January 17, 2022

To: Subcommittee on Oversight and Investigations Members and Staff

Fr: Committee on Energy and Commerce Staff

Re: Hearing on "Cleaning Up Cryptocurrency: The Energy Impacts of Blockchains"

On **Thursday, January 20, 2022, at 10:30 a.m. (EST), in the John D. Dingell Room, 2123 of the Rayburn House Office Building, and via Cisco WebEx online video conferencing**, the Subcommittee on Oversight and Investigations will hold a hearing entitled, "Cleaning Up Cryptocurrency: The Energy Impacts of Blockchains." The hearing will examine the energy and environmental impacts of certain blockchains used in cryptocurrency mining.

I. BACKGROUND

Blockchain technology is an innovative way for transactions taking place on a network of computers to be recorded on a shared, distributed public ledger.[1] Blockchains are made up of a series (or chain) of chunks of data (blocks) that have been created and validated by computers on a blockchain network.[2] Blockchain technology has many applications, ranging from executing contracts to supporting cryptocurrencies.[3]

A certain subset of blockchains in use today utilize a mechanism known as Proof of Work (PoW), which requires enormous amounts of energy to operate. Ethereum and Bitcoin, for example, are two blockchains that currently employ PoW to support their cryptocurrencies, ether (ETH) and bitcoin (BTC), respectively.[4] One analysis indicates that the energy required to validate just one ETH transaction today could power a U.S. home for more than a week, while

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[1] Congressional Research Service, *Bitcoin, Blockchain, and the Energy Sector* (Aug. 9, 2019) (R45863); *How Blockchain Applications Will Move Beyond Finance*, Harvard Business Review (Mar. 2, 2017) (hbr.org/2017/03/how-blockchain-applications-will-move-beyond-finance).

[2] *Id.*

[3] *How Blockchain Applications Will Move Beyond Finance*, Harvard Business Review (Mar. 2, 2017) (hbr.org/2017/03/how-blockchain-applications-will-move-beyond-finance).

[4] Ethereum, *Upgrading Ethereum to Radical New Heights* (Jan. 5, 2022) (ethereum.org/en/eth2/) (Ethereum has plans to migrate its platform to a less energy-intensive consensus mechanism, Proof of Stake, in 2022); Bitcoin, *Bitcoin: A Peer-to-Peer Electronic Cash System* (bitcoin.org/bitcoin.pdf) (accessed January 14, 2022).

the energy required for a BTC transaction could power a home for more than 70 days.[5] Due to their broad adoption, cryptocurrencies are predicted to remain in use for the foreseeable future, raising questions about their rising energy consumption. For example, in December 2021, BTC alone had a market cap of more than $900 billion.[6] Validation mechanisms that use less energy, such as Proof of Stake (PoS), exist, and demonstrate that exponential energy consumption is not necessary for cryptocurrencies to function.[7]

II. CRYPTOCURRENCY

The Bitcoin and Ethereum blockchains were created as decentralized systems to track and validate financial transactions of the cryptocurrencies BTC and ETH, respectively. A key feature of these systems is that they do not require the involvement of a financial institution or another entity acting as a central authority.[8] Rather, in these systems, the users themselves record and validate the cryptocurrency transactions through the process of cryptocurrency "mining."[9] Once the transactions are validated through the cryptomining process, the transactions are recorded on the corresponding blockchain.[10] The blockchain is a digital ledger containing information about all transactions that have ever occurred with a particular cryptocurrency.[11]

There are two primary ways to acquire PoW cryptocurrencies: (1) purchasing cryptocurrency already in circulation through a cryptocurrency exchange or (2) mining to acquire new coins not yet in circulation as a reward for validation activities. To mine for PoW cryptocurrencies, specialized computers make trillions of guesses per second in an effort to solve a complex puzzle.[12] The first computer to guess the correct answer is awarded new cryptocurrency coins.[13] When the correct guess has been made, other computers on the network

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[5] Digiconomist, *Bitcoin Energy Consumption Index* (digiconomist.net/bitcoin-energy-consumption) (accessed Jan. 10, 2022); Digiconomist, *Ethereum Energy Consumption Index* (digiconomist.net/ethereum-energy-consumption) (accessed Jan. 10, 2022).

[6] CoinMarketCap, *Bitcoin* (coinmarketcap.com/currencies/bitcoin/) (accessed Jan. 12, 2022).

[7] Congressional Research Service, *Bitcoin, Blockchain, and the Energy Sector* (Aug. 9, 2019) (R45863).

[8] Bitcoin, *Bitcoin: A Peer-to-Peer Electronic Cash System* (bitcoin.org/bitcoin.pdf) (accessed January 14, 2022); Ethereum, *Ethereum Whitepaper* (Jan. 5, 2022) (ethereum.org/en/whitepaper/).

[9] *See* note 7.

[10] *Id.*

[11] *Id.*

[12] *Bitcoin Uses More Electricity Than Many Countries. How is that Possible?*, The New York Times (Sept. 3, 2021).

[13] *See* note 7.

quickly verify the answer.[14] Once verified, a new block containing additional, recent transaction information is then added to the blockchain.[15] After a block is added, the validation and mining process starts over again with a new complex puzzle, and new cryptocurrency to be awarded.[16]

Importantly, the answer to the puzzles required for mining is a random string of digits that cannot be determined through mathematical calculation. Rather, a cryptocurrency miner increases their likelihood of identifying the correct answer by increasing their number of guesses, a process which increases computational power.[17] The competition inherent to PoW mining therefore incentivizes miners to continuously increase the computing power of their facilities to gain a competitive edge at winning mining rewards, creating immense energy consumption.[18]

Unlike other settings, however, increasing the computing capacity does not translate to faster mining and awarding of cryptocurrency. Rather, PoW cryptocurrencies, such as BTC and ETH, use protocols that adjust the difficulty of the puzzles to ensure one miner finds a solution at a fixed, aggregate time interval.[19] For example, in the Bitcoin network, the protocol is designed to allow a block of transactions to be validated and new BTC awarded every 10 minutes. Therefore, as additional computing power comes online to solve the puzzle, the protocol automatically adjusts the puzzle to make it more difficult to solve, ensuring it will still take approximately 10 minutes to validate any BTC transaction.[20]

In the early days of PoW mining in 2009, virtually anyone with a computer and an internet connection could earn cryptocurrency through the mining process.[21] Today, PoW miners need thousands of application-specific integrated circuits (ASICs) to have any chance of reliably earning cryptocurrency rewards on the major cryptocurrency networks.[22]

Despite the fact that the number of coins awarded per validation is structured to periodically decline over time in order to maintain scarcity, miners are making more money now than ever before given the increase in the value of the cryptocurrencies.[23] For example, in late

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[14] USENIX, *REM: Resource-Efficient Mining for Blockchains* (Aug. 2017).

[15] *See* note 7.

[16] *See* note 12.

[17] *Id.*

[18] *Id.*

[19] *Id.*

[20] *Id.*

[21] *Id.*

[22] *Id.*

[23] *$40 Million in One Day, Bitcoin Mining is More Profitable Than Ever*, U Today (Oct. 4, 2021) (u.today/40-million-in-one-day-bitcoin-mining-is-more-profitable-than-ever); *Ethereum Miners Make Multimillion-Dollar Bet on Upgrade Delay*, CoinDesk (Aug. 12, 2021) (www.coindesk.com/business/2021/08/12/ethereum-miners-make-multimillion-dollar-bet-on-upgrade-delay/); *See* note 7; *What is Bitcoin Halving and Why Does it Matter?*, U.S. News (Feb.

October 2018, one BTC miner would be rewarded with 12.5 BTC—valued at approximately $79,000—every 10 minutes.[24] In May 2020, BTC rewards were reduced by half to 6.25 BTC per validation.[25] Therefore, at the start of this month, one BTC miner was rewarded with 6.25 BTC—valued at approximately $296,000—every 10 minutes.[26]

The profitability of mining and the increase of the value of PoW cryptocurrencies over time supports massive investments in mining facilities, which require ever-increasing amounts of energy to power and cool machines.[27] From an energy consumption perspective, PoW cryptocurrencies are stuck in a vicious circle. More PoW cryptocurrency mining operations may come online as the dollar value of cryptocurrencies grow, forcing miners to expand their operations to maintain profitability.[28] Thus, there are concerns that as long as the dollar value of PoW cryptocurrency mining rewards exceed the costs of deploying, powering, and cooling mining facilities, their required energy consumption and environmental impact may grow further.[29]

III. PoW ENERGY CONSUMPTION, CARBON EMISSIONS, WASTE, AND CLEANER ALTERNATIVES

A. Energy Consumption

As the value of mining rewards has increased, more computers dedicated to mining have joined the Bitcoin and Ethereum networks, bringing more sophisticated mining equipment, such as ASICs.[30] While ASICs are more powerful and energy efficient than the hardware previously used for cryptocurrency mining, the efficiency gains have not resulted in decreased overall energy consumption because of the substantially increased scale of mining.[31]

26, 2021) (money.usnews.com/investing/investing-101/articles/bitcoin-halving-101-what-is-it-and-why-does-it-matter).

[24] *See* note 7.

[25] *Bitcoin Halving, Explained*, CoinDesk (Oct. 6, 2021) (www.coindesk.com/learn/2020/03/24/bitcoin-halving-explained/).

[26] CoinDesk, *Bitcoin* (BTC) (www.coindesk.com/price/bitcoin/) (accessed Jan. 12, 2022).

[27] *See* note 7; *Bitcoin is an energy hog. Where is all that electricity coming from?*, Vox (Jun. 18, 2019) (www.vox.com/2019/6/18/18642645/bitcoin-energy-price-renewable-china).

[28] *See* note 7.

[29] *See* note 7; *Bitcoin mining consumes 0.5% of all electricity used globally and 7 times Google's total usage, new report says*, Business Insider (Sept. 6, 2021) (https://www.businessinsider.com/bitcoin-mining-electricity-usage-more-than-google-2021-9).

[30] *See* note 7.

[31] Yo-Der Song and Tomaso Aste, *The Cost of Bitcoin Mining Has Never Really Increased*, Frontiers in Blockchain (Oct. 22, 2020); Forex Suggest, *Global Impact of Crypto Trading* (forexsuggest.com/global-impact-of-crypto-trading/) (accessed Jan. 10, 2022).

The increasing computational power of PoW blockchain networks has resulted in rapidly increasing energy consumption overall and on a per transaction basis. Last year, the estimated annual energy usage of the Bitcoin network alone grew from 77.78 Terawatt-hours (TWh) on January 2, 2021, to more than 198 TWh on November 26, 2021.[32] The Ethereum network's estimated annual energy usage over the same period grew from 14.81 TWh to more than 92 TWh.[33] The price of BTC and ETH rose in tandem with each blockchain's energy use—increasing in value more than 60 percent and 200 percent, respectively, between January 2021 and November 2021—making it profitable to bring less efficient ASICs online.[34]

B. Carbon Emissions

According to research on PoW cryptocurrencies' carbon footprint in 2020, a single ETH transaction added more than 90 pounds of CO_2 to the atmosphere, while a single BTC transaction added more than 1,000 pounds of CO_2 to the atmosphere.[35] Based on estimates of 2021 emissions, ETH mining emitted more than 22 million tons of CO_2 and BTC mining emitted more than 56.8 million tons of CO_2.[36] To put this in perspective, the global 2021 CO_2 emissions of ETH and BTC mining is equivalent to the tailpipe emissions from more than 15.5 million gasoline powered cars on the road every year.[37] Other estimates put these figures much higher.[38]

C. Electronic Waste

PoW mining operations also generate a substantial amount of electronic waste compared to the scale of their operations. Given the need to run the mining equipment continuously, even the most well-maintained mining equipment has a limited useful lifespan—lasting three to five

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[32] Digiconomist, *Bitcoin Energy Consumption Index* (digiconomist.net/bitcoin-energy-consumption) (accessed Jan. 10, 2022).

[33] Digiconomist, *Ethereum Energy Consumption Index* (digiconomist.net/ethereum-energy-consumption) (accessed Jan. 10, 2022).

[34] Statista, *Bitcoin (BTC) price per day from October 2013 to January 11, 2022* (Jan. 11, 2022) (www.statista.com/statistics/326707/bitcoin-price-index/); Statista, *Ethereum (ETH) price per day from August 2015 to January 11, 2022* (Jan. 11, 2022) (www.statista.com/statistics/806453/price-of-ethereum/); *Higher Bitcoin Prices Create Resurrection of Old Mining Rigs, Outdated Miners See New Life*, Bitcoin.com (Aug. 30, 2021) (news.bitcoin.com/higher-bitcoin-prices-create-resurrection-of-old-mining-rigs-outdated-miners-see-new-life/).

[35] Forex Suggest, *Global Impact of Crypto Trading* (forexsuggest.com/global-impact-of-crypto-trading/) (accessed Jan. 10, 2022).

[36] *Id.*

[37] *Id.*; U.S. Environmental Protection Agency, *Greenhouse Gas Emissions from a Typical Passenger Vehicle* (Mar. 2018) (www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle).

[38] *See* note 32; *See* note 33.

years under the best conditions—and quickly becomes obsolete due to advancements in newer models.[39] In 2021, it is estimated that BTC mining alone generated more than 30 thousand metric tons of electronic waste—nearly two iPhones' worth of waste per transaction.[40] Unlike the hardware that the cryptomining industry used in the past, ASICs cannot be repurposed once obsolete, presenting major challenges for proper end-of-life waste management.[41] Mismanagement of electronic waste is a growing threat to public health and the environment. Such waste contains toxic chemicals that, when disposed of in landfills or incinerated, contaminate communities' water, air, and soil.[42]

D. Cleaner Alternatives

Blockchain technology is not inherently energy intensive. In fact, there are applications that can provide secure, trusted transaction infrastructure without the same energy intensity as popular PoW blockchains. For example, PoS blockchains do not require miners to compete using computing power for zero-sum rewards.[43] Despite some setbacks and opposition from miners, Ethereum is moving forward with a transition to PoS, called Ethereum 2.0, which may use 99.99 percent less energy than a PoW blockchain.[44]

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[39] *How to prolong your ASIC miner's lifespan*, Medium (Nov. 23, 2021) (medium.com/lumerin-blog/how-to-prolong-your-asic-miners-lifespan-360b68140a04); *How long do ASICs last?*, Compass Mining (Apr. 29, 2021) (compassmining.io/education/how-long-do-asics-last/#:~:text=A%20well%20maintained%20ASIC%20typically,longer%20is%20not%20unheard%20of.); *Bitcoin Miners are Selling Old ASICs for Scrap Metal as Price Decline Hastens Obsolescence*, Yahoo (Nov. 23, 2018) (www.yahoo.com/now/bitcoin-miners-selling-old-asics-231127577.html).

[40] *Bitcoin mining producing tonnes of waste*, BBC News (Sept. 20, 2021) (www.bbc.com/news/technology-58572385); Digiconomist, Bitcoin Electronic Waste Monitor (digiconomist.net/bitcoin-electronic-waste-monitor/) (accessed Jan. 10, 2022).

[41] *Bitcoin mining producing tonnes of waste*, BBC News (Sept. 20, 2021) (ww.bbc.com/news/technology-58572385); *Bitcoin Miners are Selling Old ASICs for Scrap Metal as Price Decline Hastens Obsolescence*, Yahoo (Nov. 23, 2018) (www.yahoo.com/now/bitcoin-miners-selling-old-asics-231127577.html).

[42] World Economic Forum, *A New Circular Vision for Electronics: Time for a Global Reboot* (Jan. 2019) (www3.weforum.org/docs/WEF_A_New_Circular_Vision_for_Electronics.pdf); U.S. Environmental Protection Agency, *Cleaning Up Electronic Waste (E-Waste)* (www.epa.gov/international-cooperation/cleaning-electronic-waste-e-waste#understanding) (accessed Jan. 12, 2022).

[43] Ethereum, *Proof-of-Stake (POS)* (Jan. 3, 2022) (ethereum.org/en/developers/docs/consensus-mechanisms/pos/).

[44] *Cryptocurrency goes green: Could 'proof of stake' offer a solution to energy concerns?*, NBC News (May 25, 2021) (www.nbcnews.com/tech/tech-news/cryptocurrency-goes-green-proof-stake-offer-solution-energy-concerns-rcna1030); *Why Ethereum Miners are Making a Million Dollar Bet Against Proof-of-Stake*, Markets Insider (Aug. 13, 2021)

IV. INDUSTRY BEHAVIOR AND LOCAL IMPACTS

Cryptocurrency mining companies differ in their energy intensity and environmental impact. For example, some companies that mine for BTC draw virtually all their energy from zero-carbon renewable sources and are investing in cooling technologies that could decrease energy demand.[45] Others colocate cryptomining infrastructure to take advantage of low-cost energy in remote locations and host machines from other cryptomining companies.[46] Some cryptomining companies even purchase generation facilities to exclusively power colocated cryptomining equipment.[47]

For cryptomining facilities to operate efficiently, they need to operate constantly.[48] While many cryptomining companies have made strides in adopting renewable energy, the necessity of consistent baseload power currently prevents the mining industry from fully transitioning to renewable energy, which can be intermittent depending on the energy source, when not paired with adequate energy storage options. For example, one cryptomining facility in Kearney, Nebraska that colocated with a solar farm in an effort to use renewable energy is still only 65 percent carbon-free and relies on traditional generating sources for the remainder of its energy needs.[49]

In contrast, other cryptomining operations have relied heavily or completely on fossil fuels, re-opening or extending the life of coal and gas plants. One cryptomining company acquired two shuttered waste coal-fired power plants in Pennsylvania to generate more than 150

(markets.businessinsider.com/news/stocks/why-ethereum-miners-are-making-a-million-dollar-bet-against-proof-of-stake-1030729703); *See* note 4.

[45] Bitfarms, *Company Overview* (bitfarms.com/company/) (accessed Jan. 10, 2022); *For Miners, Liquid Immersion Creates Greater Efficiency and Less Environmental Impact*, Nasdaq (Dec. 9, 2021) (www.nasdaq.com/articles/for-miners-liquid-immersion-creates-greater-efficiency-and-less-environmental-impact).

[46] *Bitcoin Mining with Stranded Energy [Video]*,Bloomberg Quicktake (Jul. 1, 2021) (www.bloomberg.com/news/videos/2021-07-01/bitcoin-mining-with-stranded-energy-video).

[47] *Bitcoin-mining power plant raises ire of environmentalists*, AP News (Oct. 16, 2021) (apnews.com/article/bitcoin-mining-new-york-power-plant-climate-change-516dbd319394a6a30f83d94947abad20); *123-Year-Old Hydroelectric Plant Sees New Life Mining Bitcoin- Revenue 3x Higher than Selling to the Grid*, Bitcoin.com (Jul. 9, 2021) (news.bitcoin.com/123-year-old-hydroelectric-plant-sees-new-life-mining-bitcoin-revenue-3x-higher-than-selling-to-the-grid/).

[48] CoinTelegraph, *How to mine Bitcoin: A beginners guide to mine BTC* (cointelegraph.com/bitcoin-for-beginners/how-to-mine-bitcoin-a-beginners-guide-to-mine-btc) (accessed Jan. 12, 2022); *See* note 12.

[49] *See* note 44.

megawatts (MW) to support mining operations.[50] Despite neither plant being capable of cost-effective operation outside of periods of high-demand, the acquisition allows both plants to operate continuously, generating more greenhouse gas emissions per megawatt hour than traditional coal plants due to their use of waste-coal.[51] Yet another cryptomining company converted a retired coal power plant in Dresden, New York to natural gas, which now primarily generates low-cost electricity for its own mining operations rather than public consumption.[52] Another cryptomining company entered into a partnership to use energy from a coal-fired plant that was set to be retired and had not purchased any coal since 2017.[53]

Even when facilities do find sufficient, cheap power to sustain mining operations, issues persist and may negatively impact local communities. For example, in Plattsburgh, New York, during the winter of 2018, cryptomining operations made up 20 percent of total energy consumption, forcing the city to exceed its allotment of cheap hydroelectric power and purchase additional power at extra expense to residents.[54] Another cryptomining operation, attempting to

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[50] *Stronghold raises $105m to mine bitcoin with super-dirty coal waste energy at Scrubgrass, Pennsylvania*, Data Center Dynamics (Jul. 13, 2021) (www.datacenterdynamics.com/en/news/stronghold-raises-105m-to-mine-bitcoin-with-super-dirty-coal-waste-energy-at-scrubgrass-pennsylvania/) (Waste coal is a byproduct of coal mining, physical coal cleaning, and other coal preparation operations, containing matrix materials, clay and other organic and inorganic materials. Waste coal is primarily found in large piles near abandoned mines, and once burned the resulting ashes are used in mine reclamation projects.); *Stronghold Digital Mining Closes Panther Creek Plant Acquisition, Increasing Owned Power Generation Capacity to 165 Megawatts*, Yahoo (Nov. 8, 2021) (www.yahoo.com/now/stronghold-digital-mining-closes-panther-213000990.html).

[51] *Id.*

[52] *Bitcoin Mining Can Be Profitable, If You Generate the Power*, Forbes (Aug. 13, 2020) (www.forbes.com/sites/robertanzalone/2020/08/13/bitcoin-mining-can-be-profitable-if-you-generate-the-power/?sh=1b02e1075702); *Dresden Bitcoin-mining power plant raises ire of environmentalists*, Spectrum News 1 (Oct. 16, 2021) (spectrumlocalnews.com/nys/rochester/news/2021/10/16/dredsen-bitcoin-mining-power-plant-raises-ire-of-environmentalists).

[53] *Bitcoin miner Marathon signs for coal-fired electricity in Montana*, Data Center Dynamics (Oct. 16, 2020) (www.datacenterdynamics.com/en/news/bitcoin-miner-marathon-signs-coal-fired-electricity-montana/); *A bit too much? Pairing of Hardin Power Plant and Bitcoin mine stalls*, The Billings Gazette (Nov. 10, 2019) (billingsgazette.com/news/state-and-regional/a-bit-too-much-pairing-of-hardin-power-plant-and-bitcoin-mine-stalls/article_5b93ddd5-bf9e-5b6e-ba99-2ddb6fae8aa2.html); *The City That Banned Bitcoin Mining*, Vice (Mar. 16, 2018) (www.vice.com/en/article/8xk4e4/bitcoin-ban-plattsburgh-coinmint-mining).

[52] *After bitcoin mines trigger energy price spikes, mayor calls for ban*, CBC Radio (Mar. 8, 2018) (www.cbc.ca/radio/asithappens/as-it-happens-wednesday-edition-1.4565951/after-bitcoin-mines-trigger-energy-price-spikes-mayor-calls-for-ban-1.4568450).

take advantage of cheap hydroelectric power in Washington state, declared bankruptcy in 2018, leaving more than $700 thousand in unpaid utility and electricity bills.[55]

While cryptomining facilities do create jobs for communities, the number of jobs is limited due to the highly automated nature of cryptomining and limited need for skilled technicians on-site. For example, in Rockdale, Texas, during the BTC boom of 2017, a cryptomining company promised to build the largest cryptomining facility in the world—one that could eventually be used for other data-driven applications and create more than 300 jobs.[56] In reality, the facility only generated 14 of 350 promised jobs and was quickly scaled back.[57]

V. WITNESSES

The following witnesses have been invited to testify:

Ari Juels
Weill Family Foundation and Joan and Sanford I. Weill Professor
Jacobs Technion-Cornell Institute
Cornell Tech

John Belizaire
Chief Executive Officer
Soluna Computing, Inc.

Brian Brooks
Chief Executive Officer
BitFury

Steve Wright
Former Chief Executive Officer
Chelan County Public Utility District and Bonneville Power Administration

Gregory Zerzan
Shareholder
Jordan Ramis P.C.

[55] *Bitcoin Mining Firm Giga Watt Declares Bankruptcy Owing Millions*, CoinDesk (Nov. 21, 2018) (www.coindesk.com/markets/2018/11/21/bitcoin-mining-firm-giga-watt-declares-bankruptcy-owing-millions/); Douglas County Public Utility District, *About Us* (douglaspud.org/about-us/) (accessed Jan. 12, 2022).

[56] *The Hard-Luck Texas Town That Bet on Bitcoin- and Lost*, WIRED (Jul. 11, 2019) (www.wired.com/story/hard-luck-texas-town-bet-bitcoin-lost/).

[57] *Id.*