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DECENTRALIZING SUSTAINABLY—HOW BLOCKCHAIN CAN BENEFIT ENVIRONMENTAL GOALS

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INTRODUCTION

Not only have cryptocurrencies proven to be volatile assets in value, but also in recent years a volatile topic of discussion. Following the proliferation of blockchain technology has come international attention, and subsequently regulatory action.[1] While the 117th Congress paid decent attention to the growing industry, there was a distinct lack of clear guidance on environmentally sustainable practices in the industry.[2] Considering a bulk of international attention paid to blockchain centers around its environmental toll, it seems apt for federal regulatory bodies to work towards passing meaningful policy on the issue. This comes as no surprise, as it seems that a week in the crypto space is a year anywhere else. What would be recent and relevant literature on any other subject becomes obsolete in the context of blockchain and cryptocurrencies in a short period of time due to the rapidly evolving nature of the industry. As presented in this Note, with a lack of clear guidance, disparate legislation from U.S. states continues to form a patchwork approach of policy to the topic of blockchain, with notably little attention paid towards environmentally sustainable practices. While this transpires across the states, sentiments from members of the federal legislative and, most

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[1] *See, e.g.*, Jenny Gesley, *New Report on "Regulation of Cryptocurrency Around the World" Published*, LIBR. CONG.: IN CUSTODIA LEGIS (Dec. 22, 2021), https://blogs.loc.gov/law/2021/12/new-report-on-regulation-of-cryptocurrency-around-the-world-published/ [https://perma.cc/2S37-KAZP].

[2] *See, e.g.*, Jeffrey M. Kelly & Jeffrey E. Joseph, *Crossing the Wires of Energy and Cryptocurrency Policy: U.S. Congress Investigates the Environmental Impact of Crypto Mining*, NAT'L L. REV. (Feb. 4, 2022), https://www.natlawreview.com/article/crossing-wires-energy-and-cryptocurrency-policy-us-congress-investigates [https://perma.cc/H6KB-SNDU].

recently, the executive branches of government express priorities in two areas when developing policy on the matter.[3]

As this Note will outline, the concerns are generally over the sustainability of cryptocurrency mining practices and the potential for blockchain innovation to benefit environmental sustainability goals.[4] However, while the conversation transpires, there is no meaningful federal legislation addressing these concerns. The implementation of decentralized ledger technology in our country can be done with little to no carbon footprint and could serve to enhance environmentally sustainable practices across numerous industries.[5] Decentralized ledger technology, or more specifically blockchain technology, at present is in its infancy.[6] However, this infant has already facilitated a trillion-dollar cryptocurrency market.[7] While many consider blockchain to be an end-all be-all solution, this may not be the case. Blockchain technology is not infinite in its uses, but it is infinitely powerful in its potential benefits. This Note begins with a general overview of blockchain technology and some of most important features of a blockchain, followed by a discussion of the international and domestic conversations and regulatory attitude towards blockchain technology and cryptocurrencies, and it concludes with discussions on the two main points at issue for government attention in passing meaningful legislation to further sustainability goals.

I. WHAT IS BLOCKCHAIN?

A. Blockchain's Inception

A blockchain is a form of decentralized ledger technology, in that control of the ledger is dispersed across a network of users.[8] Blockchain

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[3] *See, e.g.*, Lauren Feiner, *Democratic Lawmakers Want Crypto Mining Companies to Report More Energy Usage Info*, CNBC (July 18, 2022, 4:23 PM), https://www.cnbc.com/2022/07/18/democrats-crypto-miners-should-report-more-energy-usage-info.html [https://perma.cc/4Y9X-SBGR]; Corbin Hiar, *Biden Orders Report on Climate Risk of Cryptocurrencies*, SCI. AM. (Mar. 10, 2022), https://www.scientificamerican.com/article/biden-orders-report-on-climate-risk-of-cryptocurrencies/ [https://perma.cc/UQQ8-8SXY].

[4] *See, e.g.*, Hiar, *supra* note 3.

[5] *See, e.g.*, Eric Lipton & David Yaffe-Bellany, *Crypto Industry Helps Write, and Pass, Its Own Agenda in State Capitols*, N.Y. TIMES (Apr. 10, 2022), https://www.nytimes.com/2022/04/10/us/politics/crypto-industry-states-legislation.html [https://perma.cc/3YVC-8RZ4].

[6] *See, e.g.*, HARISH NATARAJAN, SOLVEJ KRAUSE & HELEN GRADSTEIN, WORLD BANK, DISTRIBUTED LEDGER TECHNOLOGY (DLT) AND BLOCKCHAIN IV (2017).

[7] *See, e.g.*, Hiar, *supra* note 3.

[8] SATOSHI NAKAMOTO, BITCOIN: A PEER-TO-PEER ELECTRONIC CASH SYSTEM, BITCOIN.ORG 3 (2009).

first entered the international stage when the individual or individuals operating under the pseudonym Satoshi Nakamoto launched Bitcoin on its own blockchain.[9] The Bitcoin network is a decentralized peer-to-peer transaction system running based on proof-of-work protocol, meaning that it is not operated or maintained by any centralized organization.[10] The Bitcoin white paper outlines the underlying ideology behind a decentralized currency operating based entirely on individual actor participation throughout the network.[11] While existing finance typically requires an intermediary for any transaction between oneself and the party with whom they intend to transact, namely one's own bank, Bitcoin eliminates the intermediary.[12] The result is that no other party has authority over one's personal funds but the owner, so one may send and receive funds directly between themselves and another party.[13] Hence, the term peer-to-peer decentralized network.[14] Bitcoin was launched with the ideology that banks are inherently unnecessary, and rather than rely on trusting an institution, one may now rely on the immutability of blockchain.[15] While Bitcoin exists on what is called a permissionless blockchain network, there are various iterations of blockchain configurations.[16] Not only are there different characteristics to blockchain functions such as permissioned versus permissionless versus consortium, etc., but there are also multiple types of decentralized ledger software existing today.[17]

B. *Overview of the Technology*

Blockchain records transactions and other information in virtual blocks across a network of participants.[18] Blockchain, in Bitcoin's case for instance, operates on a consensus mechanism, meaning that records of the activity on the blockchain are distributed across the network of participants, referred to as nodes.[19] These blocks hold a certain amount of

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[9] *See, e.g.*, *Frequently Asked Questions*, BITCOIN, https://bitcoin.org/en/faq [https://perma.cc/7EAW-73AS] (last visited Nov. 13, 2022); NATARAJAN ET AL., *supra* note 6, at 1.
[10] NAKAMOTO, *supra* note 8, at 3.
[11] *Id.*
[12] *Id.* at 1.
[13] *Id.*
[14] *Id.*
[15] *Id.*
[16] *See, e.g.*, NATARAJAN ET AL., *supra* note 6, at 1.
[17] *See, e.g.*, Paul Belonick, *Transparency Is the New Privacy: Blockchain's Challenge for the Fourth Amendment*, 23 STAN. TECH. L. REV. 114, 128–29 (2020).
[18] *See, e.g.*, *id.*
[19] *See, e.g.*, *id.* at 128.

information each, and, generally once filled (or in Bitcoin's case, every ten minutes), the block is essentially fitted atop the previously completed block.[20] The new block is time-stamped with the completion time of the previous block to ensure a sequential order to block generation.[21] These blocks continue to stack atop each other temporally linked together through powerful cryptography into what would eventually conceptually resemble a physical chain, hence the name blockchain.[22] Once added atop the previous block, the information contained within can never be altered and exists forever on the network visible to any who knows how to access it.[23] They are unchangeable because of the time stamp on each block temporally linking them together, and because the data is distributed across the network of participants any discrepancies made to one version of the ledger are easily identifiable by the other participants who hold the correct ledger.[24] This makes blockchain networks tamperproof, as an actor altering information on the ledger would be recognized by all on the network with the same ledger, who would recognize the data as fraudulent and lock that user out of the system.[25] Because entries into the ledger cannot be altered after a block has been added, the network is referred to as immutable while also providing a level of total transparency in its display of real-time data.[26] While the system is transparent, it also ensures anonymity between parties participating in the blockchain by utilizing cryptographic hash functions.[27] Rather than anonymity, actions on blockchain networks are more aptly referred to as pseudonymous, as any individual can see the transactions taking place without any identifying information of those transacting.[28]

What began as a simple system for financial transactions is transforming into a variety of blockchain networks—the most noteworthy of which are general purpose blockchains. The most popular general purpose

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[20] NAKAMOTO, *supra* note 8, at 1.
[21] *Id.* at 2.
[22] *See, e.g.*, NATARAJAN ET AL., *supra* note 6, at 1, 9.
[23] NAKAMOTO, *supra* note 8, at 2.
[24] *See, e.g.*, Belonick, *supra* note 17, at 131–33.
[25] *See, e.g.*, *id.*
[26] *See, e.g.*, Vishal Gaur & Abhinav Gaiha, *Building a Transparent Supply Chain*, HARV. BUS. REV., May/June 2020, https://hbr.org/2020/05/building-a-transparent-supply-chain [https://perma.cc/TM3M-VBVP].
[27] *See, e.g.*, Belonick, *supra* note 17, at 134.
[28] *See, e.g.*, *id.*; BLOCKCHAIN.COM, https://www.blockchain.com/explorer [https://perma.cc/KE3S-4JNA] (last visited Nov. 13, 2022) (allowing anyone to view the transactions taking place on a given blockchain).

blockchain is the Ethereum network which houses not only the resident cryptocurrency but an entire constantly evolving virtual ecosystem with far more uses than just financial.[29] The complexity of these networks continues to grow and scale from day to day,[30] and considering the relative infancy of this technology, it is no overstatement to say that this is only the tip of the iceberg.

C. What Are Cryptocurrencies?

Cryptocurrencies in a general sense are a form of digital currency that exist as a chain of digital signatures, backed by the immutability and safety of blockchain technology.[31] This can be accomplished through the use of time-stamped transactions based on a distributed verification system made possible by blockchain technology, solving the double-spend problem with virtual currencies.[32] Critics of cryptocurrencies may posit the irrationality of trusting a computer software with no centralized body supporting it with one's finances.[33] However, the reality is that most U.S. dollars in circulation exist virtually, and, of these virtual transactions, trillions of dollars are stolen per year in hack attacks.[34] The decentralized finance system, since October 2020, has had between twenty and one hundred billion dollars locked into staking, yield farming, and lending services.[35] Comparatively, decentralized finance on blockchain networks, while not without minor flaws, protects an individual's virtual currency to a higher degree than existing technology.[36] While yearly hacks of existing tech account for trillions lost, yearly hacks of blockchain networks total

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[29] *About the Ethereum Foundation*, ETHEREUM.ORG (July 14, 2022), https://ethereum.org/en/foundation/ [https://perma.cc/XWR8-LE3T]; NATARAJAN ET AL., *supra* note 6, at 21–27.
[30] *See, e.g.*, Hiar, *supra* note 3.
[31] NAKAMOTO, *supra* note 8, at 2.
[32] *See, e.g.*, NATARAJAN ET AL., *supra* note 6, at 3, 6.
[33] *See, e.g.*, Marco Iansiti & Karim R. Lakhani, *The Truth About Blockchain*, HARV. BUS. REV., Jan./Feb. 2017, https://hbr.org/2017/01/the-truth-about-blockchain [https://perma.cc/VEE9-X8PH].
[34] *See, e.g.*, Steve Morgan, *Cybercrime to Cost the World $10.5 Trillion Annually by 2025*, CYBERCRIME MAG. (Nov. 13, 2020), https://cybersecurityventures.com/hackerpocalypse-cybercrime-report-2016/ [https://perma.cc/A5EC-PY6T].
[35] *See* DEFI PULSE, https://www.defipulse.com/ [https://perma.cc/X5XD-RFU3] (last visited Nov. 13, 2022).
[36] *See* Adam Drury, *Centralized vs Decentralized: What's the Difference?*, BLOCKLR (Aug. 17, 2018), https://blocklr.com/guides/centralized-vs-decentralized/ [https://perma.cc/VQY8-HLAW].

in the single-digit billions per year.[37] Cryptocurrencies began as a method for anonymous payment but have since proliferated into an international phenomenon spurring some countries to accept certain coins as legal currency.[38] Private organizations across the country are also beginning to accept cryptocurrency payment for services and products.[39] Each cryptocurrency resides on a respective blockchain network.[40] For instance, Bitcoin's blockchain software is still largely unchanged since its launch, yet other cryptocurrency projects are working to provide additional features with their currency unique to their blockchain.[41] For example, ZCash and Monero are both projects working to ensure the greatest level of anonymity in transactions.[42]

D. Mining on a Proof of Work Consensus Protocol

Why would anyone participate in these systems, giving their time and resources to ensure the proper function of blockchain networks? The answer is simple: for every completed block in the network and validated transaction, the validating node receives a certain amount of the cryptocurrency native to their respective blockchain.[43] This process is referred to as cryptocurrency mining, as each node lends its processing power to

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[37] *See Smart Contract Security and the Biggest DeFi Hacks of 2021*, PONTEM RES. CTR. (July 27, 2021), https://pontem.network/posts/smart-contract-security-and-the-biggest-defi-hacks-of-2021 [https://perma.cc/T2GJ-SQXJ]. It is important to note that these "hacks" are not of the blockchain networks themselves, but rather exploitations of blockchain adjacent technology such as smart contracts which contain transparent coding errors. However, since their proliferation, the number of these breaches has continued to increase.

[38] *See* Tim Fries, *El Salvador Has Adopted Bitcoin as Official Legal Tender—but Will Other Countries Follow?*, WORLD ECON. F. (Sept. 30, 2021), https://www.weforum.org/agenda/2021/09/el-salvador-officially-adopts-bitcoin-as-legal-tender-but-will-other-countries-follow/ [https://perma.cc/4G55-GLJW].

[39] *See* Ofir Beigel, *Who Accepts Bitcoin as Payment?*, 99BITCOINS (Jan. 9, 2022), https://99bitcoins.com/bitcoin/who-accepts/ [https://perma.cc/B32V-D4XU].

[40] *See* Jaime Stathis, *What Is Cryptocurrency, and How Does It Work?*, READER'S DIG. (Aug. 22, 2022), https://www.rd.com/article/how-does-cryptocurrency-work/ [https://perma.cc/MJ6J-SWZR].

[41] *See* Noelle Acheson, *Crypto Long & Short: How Bitcoin Development Is Evolving—and What's Behind It*, COINDESK (Sept. 14, 2021, 6:36 AM), https://www.coindesk.com/markets/2020/11/29/crypto-long-short-how-bitcoin-development-is-evolving-and-whats-behind-it/ [https://perma.cc/YVJ2-FMDY].

[42] *See ZCash vs Monero—the Complete Guide*, BITDEGREE, https://www.bitdegree.org/crypto/tutorials/zcash-vs-monero#:~:text=Zcash%20is%20a%20fork%20of,knowledge%20proofs%20called%20zk%2DSNARKS [https://perma.cc/H59H-LUGU] (last visited Nov. 13, 2022); *see also* Belonick, *supra* note 17, at 135.

[43] *See* Belonick, *supra* note 17, at 131.

validation of each block for payment in that blockchain's resident cryptocurrency.[44] The result is an energy intensive process that validates each transaction on the blockchain network.[45] In Bitcoin's case, there are now tens of thousands of transactions per day, which each must be recorded and validated across the network.[46] Essentially, the more powerful the hardware, the greater the number of transactions can be processed at the expense of energy.[47]

Subsequently, the more transactions validated, and blocks completed, the more a node will receive in payment of the respective cryptocurrency.[48] These participating nodes also have a general say in changes and upgrades to the system.[49] Bitcoin now being dispersed to over more than 100,000 nodes internationally results in a massive community vote mitigating the ability for one person or group of people to have more authority over the system than another.[50]

This system is referred to as proof of work protocol, and while it is not the only consensus mechanism, it is the one most apt to creating a truly decentralized network.[51] It is referred to as "proof of work," as each node in the network works to figure out a complex cryptographic puzzle to find a specific number, called a nonce.[52] The nonce is a number with over a dozen zeros following it, so each computer algorithmically searches for this number by running it, in some cases millions of times.[53] Hence the name "proof of work." Running through these numbers is a computationally challenging process, and it gets more challenging the larger the network.[54]

E. Smart Contracts

First proposed in the 1990s by Nick Szabo, smart contracts are automatically executing contracts attached to an agreement by all involved

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[44] *See id.*
[45] *See id.* at 131, n.101.
[46] *See id.* at 130–31.
[47] *See id.* at 131, 131 n.101.
[48] *See id.* at 131.
[49] *See* Belonick, *supra* note 17, at 131; *see also* Acheson, *supra* note 41.
[50] *See* Gina Jurva, *5 Questions About the Environmental Impact of Crypto-Mining*, THOMSON REUTERS (Mar. 10, 2022), https://www.thomsonreuters.com/en-us/posts/investigation-fraud-and-risk/5-questions-crypto-mining/ [https://perma.cc/CG23-NK4D].
[51] *See* Belonick, *supra* note 17, at 131, 131 n.101.
[52] *See id.*
[53] *See id.*
[54] *See id.*

parties coded to execute upon predetermined terms and conditions.[55] While the idea for smart contracts has existed for decades, until the creation of blockchain technology, there has never been a software capable of operationalizing smart contracts to the capacity presented by Szabo.[56] Paired with the immutability and transparency of blockchain networks, smart contract use is now possible across various industries with a broader functionality.[57] However, the name is somewhat of a misnomer. Smart contracts are neither smart nor traditional contracts.[58] The capabilities of smart contracts at present are only useful when transacting based on objective information; however, they are improving with the goal of eventually being able to address more subjective scenarios with accuracy.[59] Smart contracts have the potential to make many non-specialized legal jobs redundant by automating the execution of boilerplate contracts.[60]

A common example of a smart contract is the ERC-20 protocol on the Ethereum network.[61] ERC stands for "Ethereum Request for Comment," and first emerged as a smart contract issuing protocol in 2015.[62] Programmers utilize this open source protocol to launch their own cryptocurrency token on the Ethereum blockchain, as it defines a "common list of rules that all fungible Ethereum tokens should adhere to."[63] In short, this smart contract is the standard that cryptocurrencies launched on the Ethereum blockchain must follow. Once confined to on-chain transactions, the advent of hybrid smart contracts and oracle networks enable connection not only to other blockchains, but also to off-chain sites and

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[55] *See* Nick Szabo, *Smart Contracts: Building Blocks for Digital Markets* (1996), https://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart_contracts_2.html [https://perma.cc/9UYT-XX7L].
[56] *See* Tsui S. Ng, *Blockchain and Beyond: Smart Contracts*, AM. BAR ASS'N (Sept. 28, 2017), https://www.americanbar.org/groups/business_law/publications/blt/2017/09/09_ng/ [https://perma.cc/S7TH-VDRK].
[57] *See generally* Imed Bouchrika, *Use of Blockchain Technology for Legal Contracts: Will Smart Contracts Replace Lawyers?*, RESEARCH.COM (Oct. 5, 2021), https://research.com/tutorials/use-of-blockchain-technology-for-legal-contracts [https://perma.cc/7GYP-PX6Q].
[58] *See id.*
[59] *See id.*
[60] *See id.*
[61] *See* Nathan Reiff, *What Crypto Users Need to Know: The ERC20 Standard*, INVESTOPEDIA (Aug. 24, 2021), https://www.investopedia.com/tech/why-crypto-users-need-know-about-erc20-token-standard/ [https://perma.cc/AM5S-Y79B].
[62] *See id.*
[63] *Understand the ERC-20 Token Smart Contract*, ETHEREUM (Apr. 4, 2020), https://ethereum.org/en/developers/tutorials/understand-the-erc-20-token-smart-contract/ [https://perma.cc/8A8E-VXFP].

services, already yielding a massive benefit for scalability and functionality.[64] With the addition of immutability, smart contracts can safely assess the status of a transaction and automatically take actions, such as releasing a payment, recording ledger entries, and flagging exceptions in need of manual intervention.[65]

The organization Chainlink is working to increase functionality of smart contracts through oracle networks.[66] These oracles are programs existing on top of the blockchain allowing for rapid and secure transmission of information between the blockchain and off-chain services/sites.[67] While nascent at present, oracle networks and hybrid smart contracts present implications on features of traditional transactions locally, nationally, and internationally.

II. POLICY DISCUSSION AND CONSIDERATIONS

A. *The 117th Congress*

Over the past year, there have been twenty-five bills introduced regarding blockchain and/or cryptocurrency by the 117th Congress, most of which gained little traction and did not pass.[68] While not all became governing law, each bill combined presents a clear image for the desires of lawmakers for the future of blockchain innovation and cryptocurrency proliferation.[69] For instance, the Blockchain Promotion Act of 2021 specifically articulated the need for government attention towards this area of technology, to explore potential use cases for enhancing efficiency in the federal government.[70] Other acts call for greater regulatory clarity to ensure that blockchain innovation in the United States is not stifled by cumbersome regulations.[71]

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[64] *See 7 Key Takeaways from Smart Contract Summit #1*, CHAINLINK (Aug. 7, 2021), https://blog.chain.link/smart-contract-summit-1-takeaways/ [https://perma.cc/5766-YH3S].
[65] *See* Bouchrika, *supra* note 57.
[66] *See What Is a Blockchain Oracle?*, CHAINLINK (Sept. 14, 2021), https://chain.link/education/blockchain-oracles [https://perma.cc/PR49-6XNF].
[67] *See id.*
[68] Jason Brett, *Blockchain & Cryptocurrency Laws and Regulations 2022: Cryptocurrency and Blockchain in the 117th Congress*, GLOB. LEGAL INSIGHTS, https://www.globallegalinsights.com/practice-areas/blockchain-laws-and-regulations/02-cryptocurrency-and-blockchain-in-the-117th-congress [https://perma.cc/YB4Z-KQLT] (last visited Nov. 13, 2022).
[69] *Id.*
[70] *Id.*
[71] *Id.*

Other regulations were aimed at more ambitious projects, such as the creation of a digital dollar and federally distributed cryptocurrency wallets.[72] Being that there is widespread interest in regulatory guidance in cryptocurrency, the United States can work now to establish a regulatory framework which would ensure its dominance globally over cryptocurrency and blockchain innovation.[73] Considering the United States' unique position at present as the country with the most resident Bitcoin miners, regulators should take heed of the international attention on the technology and leverage this advantage.[74] This Note posits that the proliferation of blockchain technology in public use stands to revolutionize efficiency in various industries but should begin with attention towards environmental compliance and sustainability goals in two categories.

Amidst these calls for legislative action is concern by lawmakers and industry leaders over the increasing energy demands associated with major cryptocurrencies, such as Bitcoin, Ethereum, and blockchain technology generally.[75] To evaluate the environmental impact of blockchain and cryptocurrency, in January 2022, Congress began investigations and has since held some hearings on the topic.[76] While many in the international community responded to concerns by outright banning cryptocurrency, it is important to distinguish between the different types of blockchain networks and consensus mechanisms used in operating these systems.[77] The international conversation around environmental harms by cryptocurrency is primarily geared towards the proof of work consensus mechanism, and most notably the Bitcoin and Ethereum networks.[78]

B. International Point of Controversy

For several years, China held the title of cryptocurrency mining capital of the world, with only five mining pools accounting for over half of the total processing power (hash rate) dedicated to Bitcoin mining through early 2021.[79] This was the case for many years prior as well,

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[72] *Id.*
[73] *Id.*
[74] Kelly & Joseph, *supra* note 2.
[75] *Id.*
[76] *Id.*
[77] *Id.*
[78] *Id.*
[79] Raynor de Best, *Distribution of Bitcoin Mining Hashrate from September 2019 to*

until June 2021, when China set out a ban on all domestic cryptocurrency mining operations, citing in part the environmental impacts of Bitcoin and the energy demands of the network.[80] Ironically enough, this resulted in a flight of cryptocurrency miners into other nearby countries evidenced by hash rate changes, such as Kazakhstan, where the mining operations were fueled by the nation's reliance on coal power plants and non-renewable energy.[81] Prior to China once again banning cryptocurrencies, the two largest mining communities resided in two Chinese cities which suffered from an infrastructural issue due to overproduction of hydroelectric power.[82] However, given the massive coal mining industry in China, the environmental concerns derived from the notion that much of the processing power comes from coal-sourced energy.[83] According to the Law Library of Congress, eight other countries have since followed suit, not only banning mining operations, but banning cryptocurrency outright.[84] Oddly enough, while it is difficult to give an exact estimation of Bitcoin miner locations, it is clear that this ban did not eliminate all of China's hashing power.[85] Following the ban, the total hashing power of Chinese miners decreased somewhere in the area of 20% of the total global hash rate.[86]

Another country of note, weighing in on the conversation is Russia, who one month released statements citing, in part, the energy cost concerns of cryptocurrencies and cryptocurrency mining operations, alluding to a potential ban in the future.[87] Just one month later, it was

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January 2022, by Country, STATISTA (Oct. 21, 2021), https://www.statista.com/statistics/1200477/bitcoin-mining-by-country/ [https://perma.cc/XA89-UD3S].

[80] Kelly & Joseph, *supra* note 2.

[81] *Id.*

[82] Nic Carter, *The Last Word on Bitcoin's Energy Consumption*, COINDESK (Sept. 14, 2021, 4:43 AM), https://www.coindesk.com/business/2020/05/19/the-last-word-on-bitcoins-energy-consumption/ [https://perma.cc/6KGN-LMFP].

[83] Renee Cho, *Bitcoin's Impacts on Climate and the Environment*, COLUM. CLIMATE SCH. (Sept. 20, 2021), https://news.climate.columbia.edu/2021/09/20/bitcoins-impacts-on-climate-and-the-environment/ [https://perma.cc/J3KT-4D9N].

[84] Kelly & Joseph, *supra* note 2.

[85] MacKenzie Sigalos, *Inside China's Underground Crypto Mining Operation, Where People Are Risking It All to Make Bitcoin*, CNBC (Dec. 19, 2021, 7:55 PM), https://www.cnbc.com/2021/12/18/chinas-underground-bitcoin-miners-.html [https://perma.cc/E92N-PTT4].

[86] *Id.*

[87] Elena Fabrichnaya, *Russia Proposes Ban on Use and Mining of Cryptocurrencies*, REUTERS (Jan. 21, 2022, 1:40 AM), https://www.reuters.com/business/finance/russian-cbank-proposes-banning-cryptocurrencies-crypto-mining-2022-01-20/ [https://perma.cc

confirmed that the Russian legislature was working on draft legislation to do the exact opposite, and the legislature recognized some cryptocurrencies as legal tender in the country.[88]

Cryptocurrency mining has also seen substantial attention in the European Union ("EU"), with many citing concerns over mining operations inhibiting EU members' abilities to achieve sustainability goals such as carbon neutrality within the coming decades.[89] The European Securities Markets Authority warned of the potentially high environmental costs of allowing for cryptocurrency mining to continue, calling for outright proof-of-work mining bans across EU member states.[90] Most recent in the news is the narrowly avoided proof-of-work mining language included in draft legislation to provide regulatory guidance on cryptocurrency.[91] The Markets in Crypto Assets bill, prior to early March 2022, included language which would not only outlaw all types of proof-of-work mining operations, but a broad range of cryptocurrency-based activities.[92] Recognizing the poor tailoring, they struck this language from the bill and moved it forward without any ban on proof-of-work mining.[93] Aside from the close call with overbroad language, the European Commission deemed blockchain "transformative for the decades to come" and is looking to ensure Europe leads the way in blockchain innovation.[94] The European Commission has taken part in several initiatives in 2021, to work towards developing blockchain solutions such as the European Blockchain Partnership and the European Blockchain

/F3CM-QSF3]. "'The best solution is to introduce a ban on cryptocurrency mining in Russia . . . .'" *Id.*

[88] Anna Baydakova, *Russian Government Introduces Crypto Bill to Parliament over Central Bank Objections*, COINDESK (Feb. 22, 2022, 11:20 AM), https://www.coindesk.com/policy/2022/02/21/russian-government-introduces-crypto-bill-to-parliament-over-central-bank-objections/#:~:text=The%20Ministry%20of%20Finance%20is,payments%20will%20still%20be%20prohibited.&text=Russia's%20Ministry%20of%20Finance%20is,introduced%20a%20bill%20to%20parliament [https://perma.cc/X3LW-DEHP].

[89] Lindsey Choo, *The EU Voted Not to Ban Bitcoin*, PROTOCOL (Mar. 14, 2022), https://www.protocol.com/bulletins/eu-mica-vote-bitcoin-ban [https://perma.cc/7QWL-5B7L].

[90] Jason Finger, *House Committee Hearing Explores Cryptocurrency Energy Use, Bringing to Mind ESG Issues and Opportunities*, NAT'L L. REV. (Feb. 11, 2022), https://www.natlawreview.com/article/house-committee-hearing-explores-cryptocurrency-energy-use-bringing-to-mind-esg [https://perma.cc/CM8F-77BU].

[91] *Id.*

[92] Choo, *supra* note 89.

[93] *Id.*

[94] Richard Filcak, Radoslav Považan & Vincent Viaud, *Blockchain and the Environment*, EUR. ENV'T AGENCY (Mar. 25, 2021), https://www.eea.europa.eu/publications/blockchain-and-the-environment [https://perma.cc/3VAD-EQUE].

Observatory Forum.[95] Promoting its "gold standard" for blockchain development, the European Commission is looking to place the EU at the forefront of blockchain innovation and environmental sustainability is at the top of the list.[96] This standard addresses blockchain innovation strategies centered around, for instance, environmental sustainability, cybersecurity, and interoperability between networks.[97] While the United States continues to struggle with cryptocurrencies, the EU seems to have recognized that cryptocurrencies are no longer the most interesting facet of blockchain technology, instead taking aim at blockchain innovation generally.[98] All in all, while not without its concerns, the EU generally is leagues ahead of the United States in terms of blockchain innovation and policy.

Experts in the UN have released literature attesting to both the environmental concerns presented by the proliferation of blockchain, as well as the substantial benefits that widespread adoption could present towards environmental sustainability.[99] Along with institutional attention, more than sixty-five non-profit organizations openly encouraged Congress to consider the environmental impacts of crypto mining when drafting new laws.[100] In summation, cryptocurrency and blockchain technology is receiving substantial attention internationally for a myriad of reasons, with one of the most notable being the environmental costs associated with wide-scale adoption of the technology.[101] It is essential at the outset to attend to these environmental concerns with viable solutions facilitating industry growth, while rectifying potential costs.

C. State to State Patchwork Legislation

Following the ban on mining operations in China, the United States took the spot as the country providing the greatest amount of processing

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[95] *Id.*
[96] *Blockchain Strategy*, EUR. COMM'N (June 7, 2022), https://digital-strategy.ec.europa.eu/en/policies/blockchain-strategy [https://perma.cc/3NXF-M5JB].
[97] *Id.*
[98] *Id.*
[99] *In Battle Against Climate Crisis, Don't Overlook the Blockchain*, U.N. ENV'T PROGRAMME (Jan. 25, 2022) [hereinafter U.N. ENV'T PROGRAMME], https://www.unep.org/news-and-stories/story/battle-against-climate-crisis-don't-overlook-blockchain [https://perma.cc/35CT-HBGJ].
[100] Frances Yue, *More Than 60 Nonprofits Urge Congress to Consider Crypto Mining's Environmental Damage When Making Rules*, MARKETWATCH (Oct. 7, 2021, 10:26 AM), https://www.marketwatch.com/story/more-than-60-nonprofits-urge-congress-to-consider-crypto-minings-environmental-damage-when-making-rules-11633616811 [https://perma.cc/2FVD-4UGQ].
[101] *Id.*

power to the Bitcoin network.[102] With this came heightened levels of congressional scrutiny over the environmental impacts of this technology, and considerations over how best to regulate the space.[103] Senator Elizabeth Warren has been one of the most vocal critics of cryptocurrency in the 117th Congress, in large part citing the environmental considerations behind mining.[104] Warren sent letters requesting environmental footprint information from a New York–based Bitcoin mining operation, Greenridge Energy, as well as letters to six other mining companies raising concerns over the high energy toll of their operations.[105] These letters, to New York specifically, came on the heels of energy providers, like Greenridge, who utilize portions of the power they produce to mine Bitcoin and other cryptocurrencies.[106] Concerns arise when considering that one of the mining operations uses natural gas to power their processors and anticipates expanding their operations in years to come.[107] The financial appeal of cryptocurrency mining with excess energy production also drew attention from one of New York's oldest hydroelectric plants, which cites greater profits in mining cryptocurrency with the renewable energy they produce than selling it.[108] It follows as no surprise that New York state is one of the most active states in proposing legislation targeting cryptocurrency mining practices.[109]

In general, not many states have imposed direct regulations on Bitcoin mining. The general assumption from state to state is that if crypto ownership is legal, then mining is legal as well.[110] In terms of flat-out regulations, it seems that what is commonly referred to as a patchwork

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[102] Choo, *supra* note 89.
[103] *Id.*
[104] Kelly & Joseph, *supra* note 2.
[105] *Id.*
[106] *See* Rosemary Misdary, *A Bitcoin Mining Operation in the Finger Lakes Runs Up Against New York's Climate Law*, GOTHAMIST (Feb. 17, 2022), https://gothamist.com/news/bitcoin-mining-operation-finger-lakes-runs-against-new-yorks-climate-law [https://perma.cc/GYM5-VRHE].
[107] *Id.*
[108] *See* Eduardo Prospero, *Green Energy: In NY, Bitcoin Mining Saved the Oldest Working Hydroelectric Plant*, NEWSBTC (Jan. 18, 2022), https://www.newsbtc.com/news/bitcoin/green-energy-in-ny-bitcoin-mining-saved-the-oldest-working-hydroelectric-plant/ [https://perma.cc/EWA9-RJWV].
[109] *See* Heather Morton, *Cryptocurrency 2021 Legislation*, NAT'L CONF. STATE LEGISLATURES (Dec. 16, 2021), https://www.ncsl.org/research/financial-services-and-commerce/cryptocurrency-2021-legislation.aspx [https://perma.cc/279F-VRJ6].
[110] *See* Joe Dewey, *Blockchain & Cryptocurrency Laws and Regulations 2022; USA*, GLOB. LEGAL INSIGHTS, https://www.globallegalinsights.com/practice-areas/blockchain-laws-and-regulations/usa [https://perma.cc/LMR4-W9EF] (last visited Nov. 13, 2022).

regulatory approach is forming.[111] This patchwork is notably devoid of environmental considerations barring a few exceptions, instead paying substantial attention to the financial considerations around cryptocurrency and blockchain.[112] But mentioning the breadth of legislative attention to this burgeoning industry from states is essential in understanding the environmental considerations to make as blockchain continues to proliferate. In 2021 alone, thirty-three states and Puerto Rico had pending blockchain-related legislation, with seventeen states enacting legislation or adopting resolutions.[113] Some states went further than others; Arizona created a blockchain and cryptocurrency study committee, and Kentucky created a new section of existing legislation defining terms related to the commercial mining of cryptocurrency using blockchain technology.[114] Wyoming is beginning to solidify itself as a cryptocurrency safe haven, with some of the most innovative and comprehensive legislation adopted.[115] This legislation includes the creation of a staking program and advisory council, making state registration available for decentralized autonomous organizations and provides for matching funds related to carbon capture.[116]

Only the New York legislature has been active in proposing legislation on mining operations.[117] One bill which just recently died in the Assembly after almost three years aimed to establish a moratorium on cryptocurrency mining centers providing that operation of a mining center shall only be authorized following completion of environmental impact statements.[118] SB 6584 on the other hand proposes that the New York Energy Research and Development Authority conduct a study on powering crypto mining facilities with renewable energy.[119] While these were just proposals, they illuminate a concern that has been emerging on a global scale in which clear regulatory guidance could provide peace of mind.[120] Even some local governments in the past few years have taken it upon themselves to regulate cryptocurrency mining in their

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[111] *See* Todd Ehret, *US Crypto Framework Begins to Evolve: A Special Report Update*, THOMSON REUTERS (Oct. 20, 2021), https://www.thomsonreuters.com/en-us/posts/investigation-fraud-and-risk/us-crypto-framework-evolves/ [https://perma.cc/L7DZ-GTJG].
[112] *Id.*
[113] Morton, *supra* note 109.
[114] *Id.*
[115] *Id.*
[116] *Id.*
[117] *Id.*
[118] *Id.*
[119] Morton, *supra* note 109.
[120] *Id.*

municipalities.[121] Across the country in a far less densely populated state, Missoula County, Montana, crafted new regulations making it one of the first localities to enact legislation on cryptocurrency mining.[122] The legislation would require equivalent amounts of renewable energy to be developed or bought to the amount of energy consumed by mining operations.[123] While local officials indicated their intention was not to prohibit the industry in the county, this resulted in a large mining organization, Hyberblock, entering bankruptcy amid the Bitcoin price dip at the beginning of the COVID-19 pandemic.[124]

D. Federal Attention

Along with the numerous bills geared towards establishing regulatory guidance on cryptocurrency and blockchain innovation proposed in 2021 in Congress and in various states, the House Committee on Energy and Commerce's Subcommittee on Oversight and Investigations held a hearing discussing externalities of crypto mining.[125] While the opinions of experts on the panel differed in ways, there seemed to be a consensus in looking for energy efficient alternatives to guide the industry forward.[126] Held on January 20, 2022, this meeting explored topics such as blockchain and its energy consumption impacts on the climate, how cryptocurrency mining can affect utilities management of energy resources and price of electricity, and how to find a balance between green energy goals and economic development of blockchain.[127] The discussion largely focused on proof-of-work cryptocurrency networks, namely Ethereum and Bitcoin, and how to make them more environmentally sustainable.[128] Potential solutions arose in two primary categories: utilizing renewable energy, or turning to other blockchain networks that use lower energy-consuming consensus mechanisms.[129] Experts on the panel suggested the benefits that mining operations could have on the renewable energy industry, as

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[121] *Id.*
[122] *See* Megan Myscofski, *Cryptocurrency Has Raised Environmental Concerns—Local Governments Are Stepping In*, NPR (May 25, 2021, 4:42 PM), https://www.npr.org/2021/05/25/1000274002/cryptocurrency-has-raised-environmental-concerns-local-governments-are-stepping- [https://perma.cc/ZQC8-K4WS].
[123] *Id.*
[124] *Id.*
[125] Kelly & Joseph, *supra* note 2.
[126] *Id.*
[127] Finger, *supra* note 90.
[128] *Id.*
[129] *Id.*

well as the area of using much of the energy production that goes to waste each year.[130] Overall, it was apparent that Congress is interested in two sustainability priorities following this hearing: sustainable cryptocurrency mining and the benefits blockchain can yield in working towards sustainability goals.[131]

Most recently, President Biden released an executive order on blockchain technology and cryptocurrency, paying attention to the desire for technological innovation, while also ensuring mitigation of environmental impact.[132] This order, among many other things, requires reports from different government agencies evaluating the potential for the technology to impede or advance efforts to tackle climate change, at home and abroad, as well as its potential environmental costs.[133] These reports should specifically address blockchain's potential use for monitoring or mitigating its impacts on climate, such as the exchanging of liabilities, and implications for energy policy relating to grid management and reliability.[134] In sum, this executive order echoed the sentiments expressed by the congressional hearing on blockchain's environmental impacts setting out two main goals.[135] First, this Note will evaluate blockchain's environmental impacts, which most certainly refers to the energy-intensive potential for proof-of-work mining.[136] Second, this Note will evaluate of how blockchain technology can benefit environmental sustainability goals.[137]

E. Summary

As displayed in this section, there is a displayed interest in regulation of the blockchain and cryptocurrency industry generally on a local, state, federal, and international level.[138] While few substantive pieces of regulation on the area exist, the space is subject to growth in a patchwork approach across the states.[139] Being that few states attend to the growing environmental concerns of blockchain, and more towards its financial potential, broad federal attention could be essential to establish

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[130] *Id.*
[131] *Id.*
[132] *See* Exec. Order No. 14,067, 87 Fed. Reg. 14143 (Mar. 9, 2022).
[133] *Id.*
[134] *Id.*
[135] *Id.*
[136] *Id.*
[137] *Id.*
[138] Exec. Order No. 14,067 (2022).
[139] *Id.*

a framework for this industry to advance while attending to sustainability priorities. Following the federal attention towards the industry, two main points of consideration on the environmental front appear in both congressional language and executive branch guidance.[140]

First, it is necessary to limit the environmental impact of proof-of-work mining operations without stifling those operating in the industry of cryptocurrency mining. It is imperative that this guidance is based on accurate information and proposes nuanced solutions as opposed to outright bans as seen by actions from states and other nations. Secondly, there is considerable interest in the ways that advancements in blockchain technology can work to benefit achieving sustainability goals.[141] While this technology appears in some literature as being inherently flawed in that it is highly energy intensive, as previously discussed, this is simply no longer the universal truth.[142] Advancements and innovation in blockchain are already proving to yield potential benefits towards sustainability goals across industries but most notably in supply chains and environmental monitoring.[143] The following section addresses the first of the environmental considerations, the real impact of proof-of-work mining primarily from the perspective of the Bitcoin network, as well as areas for regulatory solutions to mitigate environmental costs without banning the practice.

III. ENVIRONMENTAL IMPACT OF PROOF-OF-WORK MINING AND HOW IT CAN BENEFIT THE RENEWABLE ENERGY MARKET

A. *The Environmental Impact of Bitcoin Proof-of-Work Mining*

This section sets out to outline the energy costs of proof-of-work mining through the example of the Bitcoin network and explain how regulatory guidance could leverage the U.S. position in the Bitcoin mining community to maximize efficiency of the country's renewable energy grid, while also dispelling some common misconceptions of Bitcoin's environmental impact. There are a few concerns when it comes to Bitcoin proof-of-work

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[140] *Id.*
[141] *Id.*
[142] *See* Christopher Felton, *With Great Power Comes Great (Eco) Responsibility—How Blockchain is Bad for the Environment*, GEO. ENV. L.R. BLOG (Apr. 6, 2019), https://www.law.georgetown.edu/environmental-law-review/blog/with-great-power-comes-great-eco-responsibility-how-blockchain-is-bad-for-the-environment/ [https://perma.cc/QWP6-K5MF].
[143] *Id.*

mining generally, one in the amount of energy consumed and another in the type of energy used. In general, while energy usage is high, the tangible negative impact on climate change and the environment is low.[144] To recap, the high energy toll of the Bitcoin blockchain derives from the proof-of-work consensus mechanism.[145] The cryptographic puzzle will only increase in difficulty as more participants enter the network.[146] However, crypto-miners' implicit interest lies in being as electrically efficient as possible, considering energy consumption is their main expense after the initial investment into hardware.[147] They generally pursue renewables like solar, wind, hydropower, and non-renewable energy that would have otherwise been wasted.[148] Prior to China's ban on cryptocurrency mining, the two largest mining communities in the world centralized in cities with an overabundance of hydroelectric energy.[149] Early research on the environmental costs of Bitcoin mining was rife with criticism; however, a common error in these papers was to conflate carbon footprint directly with quantity of energy consumption.[150] There are two factors that influence carbon footprint: energy consumption and the type of fuel consumed.[151] These findings therefore did not accurately reflect Bitcoin's carbon footprint, as they did not account for forms of renewable fuel.[152]

The Cambridge University Center for Alternative Finance ("CCAF") provides data on Bitcoin's electrical toll but concedes that it is generally impossible to determine exactly how much energy Bitcoin mining uses because there are many unknown variables.[153] The CCAF estimates a broad range between 34 and 351 TWh (Terawatt hours) per year, their best estimate being around 94 TWh per year as of August 29, 2021.[154] As of March 2022, the CCAF estimates that the Bitcoin network will consume an average of approximately 134 TWh per year.[155] Given that the

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[144] Jurva, *supra* note 50.
[145] *Id.*
[146] *Id.*
[147] *Id.*
[148] *Id.*
[149] Carter, *supra* note 82.
[150] *Id.*
[151] *Id.*
[152] *Id.*
[153] Stephen T. Gannon & Lisa Weingarten Richards, *How Bitcoin Can Favorably Impact Climate Change (Despite What You May Have Heard)*, BLOCKCHAIN L. CTR., Sept. 28, 2021, at 1, 1.
[154] *Id.*
[155] *See generally Cambridge Bitcoin Electricity Consumption Index*, CAMBRIDGE CTR. ALT. FIN., https://ccaf.io/cbeci/index [https://perma.cc/4B5N-HXDV] (last visited Nov. 13, 2022).

total global energy use provided by the International Energy Agency is around 167,000 TWh per year, Bitcoin's energy consumption equates to less than one-thousandth of global energy consumed.[156] To compare it to a longstanding industry, aluminum smelting alone uses around 1,020 TWh of electricity per year, roughly ten times that of the Bitcoin network.[157] The United States alone sees around 2,000 TWh of energy wasted each year, with 206 TWh of electricity produced by powerplants that never reaches customers.[158] While the actual estimates vary dramatically, it is likely that the Bitcoin mining energy grid is also far cleaner than the average power grid. Estimates for the percentage of miners using renewable energy range from the high thirties to over seventy percent of the whole industry running on renewable energy.[159] Research from the University of Cambridge shows that renewable energy share of Bitcoin mining pools is up to as high as seventy-eight percent, with the largest share generally sustained by hydroelectric power.[160]

It is popular among Bitcoin opponents to make the blanket claim that Bitcoin miners use as much electricity as a small country, such as Argentina.[161] However, these estimates generally do not include the country's total energy consumption.[162] For example, Argentina consumed eighty megatons of oil in 2018, which equates to over seven times the TWh of the current Bitcoin network estimate.[163] So while claiming Bitcoin mining uses as much electricity as a small nation may technically be true based on a limited sample set, it simply does not provide a complete picture.[164] Some older literature considered Bitcoin network energy consumption numbers in a vacuum, but when viewed in a broader perspective, it is

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[156] Gannon & Richards, *supra* note 153, at 2.

[157] *Id.*

[158] *Id.*

[159] *Id.* at 2–3.

[160] Stephen Stonberg, *How Blockchain and Cryptocurrencies Can Help Build a Greener Future*, WORLD ECON. F. (June 17, 2021), https://www.weforum.org/agenda/2021/06/how-blockchain-and-cryptocurrencies-can-help-build-a-greener-future [https://perma.cc/5WM5-88SM].

[161] Rahul Singh, *How to Make Cryptocurrency More Sustainable*, WORLD ECON. F. (Nov. 15, 2021), https://www.weforum.org/agenda/2021/11/how-to-make-bitcoin-and-cryptocurrency-sustainable-renewable-energy-blockchain-crypto-mining/ [https://perma.cc/K9MV-R838].

[162] *Bitcoin Energy Consumption Index*, DIGICONOMIST, https://digiconomist.net/bitcoin-energy-consumption/ [https://perma.cc/G8QX-L8TU] (last visited Nov. 13, 2022).

[163] Lewis Page, *Bitcoin Mining Uses Tiny, Insignificant Amounts of Energy*, VERDICT (Mar. 19, 2021, 9:36 AM), https://www.verdict.co.uk/bitcoin-mining-uses-very-little-energy/ [https://perma.cc/HXL2-2SA9].

[164] Gannon & Richards, *supra* note 153, at 3.

simply not as impactful as much early literature anticipated.[165] That same literature also generally assessed from the assumption that Bitcoin mining operations were largely fueled by the coal industry considering the low cost of power.[166] The CCAF, in assuming the worst possible scenario for mining operations, being that they were exclusively powered by dirty energy like coal, would still only account for roughly .35% of the world's yearly emissions.[167] Additionally, much early research should be taken with a grain of salt, considering that even critical literature conceded that predictions on crypto mining's environmental impact "varies wildly from study to study."[168] While the earlier research raised some important initial considerations, as the technology improves and the industry proliferates,[169] those concerns generally fade in the wake of innovation. As already mentioned, a week in the crypto space is a year anywhere else.

While anyone can purchase a processor to begin mining cryptocurrency like Bitcoin, at this point it would simply be financially imprudent for the average user.[170] In the early days of the Bitcoin network, solo mining operations were feasible and popular, but as mining pools entered the scene, the computational challenge increased.[171] Mining pools, simply put, are virtual groups in which individuals can join, typically for a cost, and lend out their processing power to search a specific range of numbers for the nonce.[172] If two individuals took part, then the software would

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[165] *See* Jeff Thomson, *Tragedy of the Energy Commons: How Government Regulation Can Help Mitigate the Environmental and Public Health Consequences of Cryptocurrency Mining*, 11 SEATTLE J. TECH., ENV'T & INNOVATION L. 77, 79 (2020).
[166] *Id.* at 90.
[167] Gannon & Richards, *supra* note 153, at 5 n.13.
[168] Thomson, *supra* note 165, at 92.
[169] *See* Keira Wright, *Immersive Cooling Tech Could Help Bitcoin Mining Go Green by 2030*, COINTELEGRAPH (Oct. 29, 2021), https://cointelegraph.com/news/immersive-cooling-tech-could-help-bitcoin-mining-go-green-by-2030 [https://perma.cc/KK98-VS93].
[170] *See* Sujith Somraaj, *How Much Does It Cost To Mine 1 Bitcoin?*, DECRYPT (July 16, 2022), https://decrypt.co/105251/how-much-does-cost-mine-1-bitcoin [https://perma.cc/AJJ2-VTD9].
[171] *See* Rakesh Sharma, *Are Large Mining Pools Bad for Cryptocurrencies?*, INVESTOPEDIA (Dec. 18, 2021), https://www.investopedia.com/tech/are-large-mining-pools-bad-cryptocurrencies/ [https://perma.cc/PJ87-72R7]; *see also* Marko Tarman, *What Is Solo Mining and How Does It Work?*, NICEHASH BLOG (Jan. 14, 2022), https://www.nicehash.com/blog/post/what-is-solo-mining-and-how-it-works [https://perma.cc/2BDY-NR5Y]; Alex Lielacher, *Is Solo Bitcoin Mining Making a Comeback?*, CRYPTONEWS (Feb. 19, 2022, 7:00 AM), https://cryptonews.com/exclusives/solo-bitcoin-mining-making-comeback.htm [https://perma.cc/Z5QX-KSMC].
[172] *Bitcoin Mining Pools vs. Mining Farms*, PULSELIVE (Jan. 25, 2021, 12:58 PM), https://www.pulselive.co.ke/business/bitcoin-mining-pools-vs-mining-farms/mx971nv [https://perma.cc/2FKS-XQSJ].

split the range of numbers to search between each party, increasing the likelihood of one finding the nonce quickly.[173] The likelihood of finding increases as difficulty decreases the number of individuals taking part in the network.[174] In most cases, if successful in validating a block the reward would be distributed across the network of processing power providers.[175] With mining pools came large mining operations, known as Bitcoin mining farms, which work to achieve the same as pools but by splitting up the processing requirement across a series of their own processors.[176] Hence why it is now imprudent for an individual to attempt to participate in solo Bitcoin mining as they are up against hundreds of thousands of nodes with millions invested in processing equipment.[177] These farms are what pose the greatest environmental concern and are what industry leaders and regulators are largely discussing when evaluating environmental concerns.[178] This equipment takes a lot of electricity to run, and the more processors per farm, the greater the electrical toll on the associated grid.[179]

B. Regulatory Solutions and the U.S. Energy Market

Regulation of cryptocurrency mining does not implicitly entail limitation of mining operations but instead leaves the door open for innovate nuanced solutions to ensure that blockchain innovation and tax revenue from mining operations remain firmly rooted in the United States. The solutions would look towards mitigating environmental cost and utilizing the United States' massive amount of wasted energy resources. If done so properly, blockchain could be a means to accelerate the use of renewable energy sources such as wind and solar. The technology dictates that as network participation grows the energy toll will

[173] *Id.*
[174] *See* Shobhit Seth, *How Do Cryptocurrency Mining Pools Work?*, INVESTOPEDIA (Aug. 25, 2021), https://www.investopedia.com/tech/how-do-mining-pools-work/ [https://perma.cc/42XU-X9R9].
[175] *Id.*
[176] *Id.*
[177] *Id.*
[178] *See* Elizabeth Kolbert, *Why Bitcoin Is Bad for the Environment,* NEW YORKER (Apr. 22, 2021), https://www.newyorker.com/news/daily-comment/why-bitcoin-is-bad-for-the-environment [https://perma.cc/H4ZZ-WMRG].
[179] *See* Oscar Gonzalez, *Bitcoin Mining: How Much Electricity It Takes and Why People Are Worried*, CNET (July 18, 2022, 2:08 PM), https://www.cnet.com/personal-finance/crypto/bitcoin-mining-how-much-electricity-it-takes-and-why-people-are-worried/ [https://perma.cc/8FBS-58JT].

subsequently increase as well.[180] So, it is imperative to devise a present solution to prepare for more widespread adoption as more individuals, nations, and private institutions continue stepping into the Bitcoin space.[181]

A regulatory solution lies in stranded energy, or energy produced but not consumed, therefore going to waste.[182] Renewable resources are most susceptible to this phenomenon, most notably wind and solar power, which operate on what's referred to as a duck-worth curve.[183] A duck-worth curve refers to the variations in production of wind and solar power during different times of day.[184] In the United States, for example, three U.S. electricity markets have seen a delay in solar and wind, with nearly half of the total wind and solar energy produced, and without leaps and bounds in solar/wind batteries, this is unlikely to change.[185] Incentivizing cryptocurrency miners generally with environmental sustainability tax credits for those utilizing wind and solar energy is a viable short-term solution to these energy concerns. A general incentive to centralize around these areas already exists, considering the Levelized Cost of Energy ("LCOE") for solar and wind has fallen ninety percent and seventy-one percent respectively in the past decade.[186] According to one estimate, the unsubsidized cost of solar and wind energy are around three to four cents and two to five cents per kilowatt hour, respectively.[187] The general misconception is fear over Bitcoin mining operations depriving a family of the energy they need.[188] This is not currently and would not be the case in the future if implemented properly and could have the side effect of centralizing blockchain innovators around areas of surplus renewable energy. These concerns are generally moot in most instances where solar and wind power are developed, which have limited transmission capacity, with few users nearby to utilize the energy produced.[189]

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[180] *See* Adam Hayes, *Blockchain Facts: What Is It, How It Works, and How It Can Be Used*, INVESTOPEDIA (Sept. 27, 2022), https://www.investopedia.com/terms/b/blockchain.asp [https://perma.cc/VM2Z-PL9J].
[181] Page, *supra* note 163.
[182] Gannon & Richards, *supra* note 153, at 2.
[183] SQUARE, BITCOIN IS KEY TO AN ABUNDANT, CLEAN ENERGY FUTURE 2 (2021) [hereinafter BITCOIN CLEAN ENERGY INITIATIVE MEMORANDUM].
[184] *Id.*
[185] *See id.*; Kelly & Joseph, *supra* note 2.
[186] BITCOIN CLEAN ENERGY INITIATIVE MEMORANDUM, *supra* note 183, at 2.
[187] *Id.*
[188] *See Why Bitcoin's Energy Problem Is So Hard to Fix*, BLOOMBERG PRO. SERV. (Mar. 21, 2022), https://www.bloomberg.com/professional/blog/why-bitcoins-energy-problem-is-so-hard-to-fix-quicktake/ [https://perma.cc/7F2F-CPHP].
[189] *See id.*

In the first ever congressional hearing on the environmental impact of cryptocurrency and blockchain, experts raised this consideration when questioned about solutions to environmental concerns of large mining operations.[190] In John Belizaire's testimony, he proposed an interesting solution that utilization of the wasted energy produced by renewable resources across the nation, could in a sense supercharge the renewable energy industry.[191] These resources typically go to waste because of the natural limitations of wind and solar power, and while there is no viable way to store that energy, transference to computing power would act as a "better battery."[192] Because mining operations can be turned on and off easily,[193] coordinating on time with natural changes in energy production is plausible. Additionally, the portability of mining operations could benefit the ability to locate areas based on underused energy transmission and distribution.[194] There are genuine concerns with this approach, namely that it is not pragmatic to assume large mining operations will relocate or choose these locations.[195] The reason being that relocation and centralizing around these renewable sources would be expensive, and considering the volatility of Bitcoin, it may seem financially imprudent for companies to invest in this manner.[196] But this argument could fall short when considering the relative ease in portability of Bitcoin mining operations and the enormous incentives in the form of cheap and readily accessible energy sources. The logic of this critique implies that few large bitcoin operations would even exist considering the high upfront cost of equipment. This type of transitory behavior was present in China when cryptocurrency mining was still legal, as most miners would switch to hydroelectric power during seasons with heavy rain but then revert to coal powered electricity afterwards.[197] Because the only operating expense is electricity,[198]

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[190] Kelly & Joseph, *supra* note 2.
[191] *Id.*
[192] *Id.*
[193] *See A Detailed Guide on How Cryptocurrency Mining Works*, FREEMAN L. (Sept. 6, 2022), https://freemanlaw.com/mining-explained-a-detailed-guide-on-how-cryptocurrency-mining-works/ [https://perma.cc/ZU8H-D8CR]; *see also* Quang Phan, *What Is Bitcoin Shutdown Price? Risks and Scenarios*, COIN98 (June 8, 2022), https://coin98.net/what-is-bitcoin-shutdown-price [https://perma.cc/FP2M-QJPZ].
[194] *Id.*
[195] *See* Kelly & Joseph, *supra* note 2.
[196] Cho, *supra* note 83.
[197] Mona Dajani, *Green Bitcoin Does Not Have To Be an Oxymoron*, BLOOMBERG L. (Apr. 26, 2021, 4:01 AM), https://news.bloomberglaw.com/business-and-practice/green-bitcoin-does-not-have-to-be-an-oxymoron?context=search&index=0 [https://perma.cc/KUW5-QHTP].
[198] *See id.*

there is enormous incentive to seek out cheaper and more abundant sources. Not only is there incentive, but industries also have an interest in renewables.[199] This is evidenced for instance by the cryptocurrency organizations Argo and DMG contracting to launch a new Bitcoin mining pool operating exclusively on renewable energy.[200]

Currently, Texas is leading the charge on the Bitcoin mining front, with multiple large Bitcoin mining operations now moving to Texas for the state's renewable energy surplus.[201] State legislators are expressing excitement over the potential for Bitcoin mining to assist in fueling the renewable energy industry, while also receiving value from their production of renewables that would have been otherwise unusable.[202] On the topic of Texas, developing technology is working to capture natural gas waste produced by oil fields that is typically burned, releasing methane emissions into the atmosphere.[203] This technology would be able to capture this waste and convert it into electricity for Bitcoin mining operations, reducing emissions twenty-four-fold comparatively to venting the methane.[204] This technology is certainly promising, but it follows with concerns over the potential for a Bitcoin price crash, which would make these projects less financially pragmatic.[205]

C. Fitting Bitcoin Mining into Existing Environmental and Regulatory Frameworks

There are a handful of regulatory avenues with which to approach this renewable energy solution. There are critiques of some government agencies for mismanaging the definitions and labeling of cryptocurrency miners, so while mined cryptocurrency is taxed as revenue, miners do not fall under the regulatory scope of a government body like Financial Crimes

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[199] *See id.*
[200] *Id.*
[201] Shawn Tully, *Texas Is Becoming the World Capital for Bitcoin Mining—and 7 Companies Are Fighting for Territory*, FORTUNE (Feb. 10, 2022, 7:00 PM), https://fortune.com/2022/02/10/texas-world-capital-bitcoin-mining-companies/ [https://perma.cc/9BPH-8AJU].
[202] *Id.*
[203] Gannon & Richards, *supra* note 153.
[204] *Id.*
[205] John Bogna, *What Is the Environmental Impact of Cryptocurrency?*, PCMAG (Jan. 8, 2022), https://www.pcmag.com/how-to/what-is-the-environmental-impact-of-cryptocurrency#:~:text=The%20most%20obvious%20environmental%20impact,new%20digital%20coins%20are%20created.&text=Electricity%20may%20seem%20like%20a,atmosphere%20and%20worsens%20climate%20change [https://perma.cc/9XQ7-QHH8].

Enforcement Network ("FinCEN").[206] FinCEN had the opportunity to regulate and license cryptocurrency miners if labeled as money transmitters for instance, in which case it would have greater regulatory scrutiny over the domestic operations of large mining farms.[207] In a general sense, given the data and arguments set forth in this Note, it is feasible for a regulatory framework based on renewable energy tax credits. An additional incentive could derive from direct carbon taxation. While it would be difficult to identify individual miners for this tax, large mining operations are much more easily identified.[208]

Another regulatory body that could play a role in working towards environmental sustainability of cryptocurrency mining is the Securities and Exchange Commission ("SEC").[209] If bitcoin were labeled a security, the SEC could have greater authority over the regulatory future of the industry and a more direct role in the environmental and energy goals of the industry.[210] The SEC could take this role in a variety of ways, such as using its authority to disclose the environmental impact of mining operations or impose regulations working to reduce said impact.[211] Bitcoin and Ethereum may be outside of the SEC's regulatory purview,[212] however, there is still the opportunity to enforce some environmental standards on new cryptocurrencies entering the market. While this may not be an ideal scenario, considering the attention given by state legislation towards the financial aspects of cryptocurrencies, guidance from the SEC may be a viable solution to form a path for the developing patchwork.

Given the discussion around environmentally sustainable regulatory solutions, it is time to move past the typical bad press equating proof-of-work mining to blockchain generally as a technology. In line with the second of the two federal interests presented by this Note towards blockchain technology, regulators can leverage innovation in the space to work towards

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[206] Amanda Gulli, *[Un]Sustainability of Bitcoin Mining*, 46 RUTGERS COMPUT. & TECH. L.J. 95, 102 (2020).
[207] *Id.*
[208] *Id.* at 121.
[209] Julia Cusick, *Release: The SEC's Regulatory Role in Greening the Blockchain and Regulating Digital Asset Markets*, CTR. FOR AM. PROGRESS (Oct. 4, 2021), https://www.americanprogress.org/press/release-secs-regulatory-role-greening-blockchain-regulating-digital-asset-markets/ [https://perma.cc/ZAS2-WK9J].
[210] *Id.*
[211] *Id.*
[212] Bob Pisani, *Bitcoin and Ether Are Not Securities, but Some Initial Coin Offerings May Be, SEC Official Says*, CNBC (June 14, 2018, 2:43 PM), https://www.cnbc.com/2018/06/14/bitcoin-and-ethereum-are-not-securities-but-some-cryptocurrencies-may-be-sec-official-says.html [https://perma.cc/2TUJ-P7WD].

several environmental sustainability goals across various industries. With proper guidance, different industries may begin the transition—as many already have—to monitoring with blockchain technology solutions, be it utilizing a public network or a private consortium for their efficiency. In short, not only are these environmental concerns rectifiable on the proof-of-work front, but they are also now for many reasons not relevant. Federal regulatory attention towards the innovations in blockchain technology must now recognize that proof-of-work mining—and environmental concerns stemming from it—is not synonymous with blockchain generally.

IV. BLOCKCHAIN FOR SUSTAINABILITY GOALS—MITIGATING CONCERNS OVER THE FUTURE OF THE INDUSTRY, ENVIRONMENTAL MONITORING, REGULATORY COMPLIANCE, AND SUPPLY CHAINS

A. Environmentally Sustainable Blockchain Development

Not all blockchains are created equal and few are the same as the first. Ethereum's introduction in 2013 marked the beginning of the development race towards improving blockchain technology past its initial purposes.[213] This section sets out to discuss the environmental considerations around emerging blockchain-based solutions and cryptocurrencies geared towards sustainability and the ways in which the technology can assist in achieving sustainability goals, thus, addressing one of the considerations set for by legislators and the recent executive order. The reality seems to be that most blockchain innovators are renewable energy oriented.[214] There is a collective goal by industry leaders to make the industry entirely green within the next few years and have a zero-carbon footprint by 2030.[215] As it follows, to ensure continued innovation in blockchain technology, narrowly tailored regulatory goals towards environmental sustainability are necessary in ensuring innovation in areas of the blockchain space that do not pose a threat but stand to benefit sustainability.

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[213] Andrew R. Chow, *The Man Behind Ethereum Is Worried About Crypto's Future*, TIME (Mar. 18, 2022, 6:00 AM), https://time.com/6158182/vitalik-buterin-ethereum-profile/ [https://perma.cc/2WK9-3NB5].

[214] Julian Jackson, *The Blockchain Projects Making Renewable Energy a Reality*, COINTELEGRAPH MAG. (Mar. 18, 2022), https://cointelegraph.com/magazine/2022/03/18/blockchain-projects-making-renewable-energy-reality [https://perma.cc/C7Z3-P6NH].

[215] *Sustainability Solution or Climate Calamity? The Dangers and Promise of Cryptocurrency Technology*, U.N. NEWS (June 20, 2021) [hereinafter U.N. NEWS], https://news.un.org/en/story/2021/06/1094362 [https://perma.cc/B4UV-NP97].

How to integrate regulatory guidance in a fashion that ensures healthy proliferation of the blockchain space and traditional businesses interested in deploying blockchain technology is the question. These aforementioned energy-efficient options make blockchain solutions in various industries a viable and much more efficient alternative to the existing data storage structures in wide use.[216] This holds the most truth in the supply chain space, where blockchain technology could yield the most benefits for organizations on a variety of fronts. Most notably, blockchain deployment stands to better environmental compliance and general regulatory compliance in supply chains. The enhanced record-keeping capabilities of these networks and real-time monitoring of each aspect of the supply chain at any point in time throughout the cycle presents an unparalleled means for achieving environmental compliance.[217]

All but the entirety of international considerations around the environmental impact of blockchain networks center around the discussion of the proof-of-work consensus mechanism to ensure security and immutability of the network. With recent developments in the technology, however, emerging consensus mechanisms can effectively achieve the same goals without the high energy toll. The proof-of-stake consensus mechanism, for instance, differs in that, instead of investing in equipment to process transactions, the amount of the resident cryptocurrency of the blockchain network locked into a network determines processing and validation.[218] A switch to proof-of-stake would decrease energy cost by around 99.99% comparatively to a proof-of-work network, allowing anyone with a laptop to run a node if staking that resident cryptocurrency.[219] Ethereum, the second largest proof-of-work and second largest blockchain network, intends on switching to proof-of-stake to reduce its energy consumption, of which a suspected 99.99% decrease will follow.[220] At present, a variety of other blockchain networks already utilize proof-of-stake. Namely, Solana, Avalanche, Cardano, and Cosmos all rely on proof-of-stake for reaching consensus.[221] The system functions by allowing any individual to put money into the system, referred to as staking, to participate

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[216] Nicola Friedman & Jarrod Ormiston, *Blockchain as a Sustainability-Oriented Innovation?: Opportunities for and Resistance to Blockchain Technology as a Driver of Sustainability in Global Food Supply Chains*, TECH. FORECASTING & SOC. CHANGE, Feb. 2022, at 1, 2, 3, 10.
[217] U.N. NEWS, *supra* note 215.
[218] Finger, *supra* note 90.
[219] *Id.*
[220] *Id.*
[221] Jurva, *supra* note 50.

in the network.[222] This functionality is made possible by smart contracts, which act as the mechanism locking in the funds for a set period of time and for that time granting validating rights to the user.[223] Just as proof-of-work rewards for investment into processing equipment, proof-of-stake rewards for investing financially, as users typically hope to receive large returns that vary wildly, but generally fall into the range of 7% to 1,000%.[224]

Following heightened international scrutiny, organizations arose looking to work towards environmental sustainability goals across the blockchain industry.[225] For instance, the Crypto Climate Accord ("CCA"), "inspired by the Paris Climate Agreement, the CCA is a private sector–led initiative for the entire crypto community focused on decarbonizing the crypto and blockchain industry."[226] New reports from the United Nations Environment Programme and Social Alpha Foundation look to evaluate how blockchain can work to expand access to energy in developing nations due to greater accuracy in energy monitoring, generation, and distribution through blockchain's efficient use of data.[227] But these reports ultimately suggest that "policymakers also need to adjust regulations to spur the development of future energy systems while mitigating environmental risks."[228] Additional assessment from the UN addresses blockchain and cryptocurrencies potentially powerful role in sustainable development.[229] This role would be due primarily to the technologies' transparency and resistance to tampering and fraud, providing a trusted and verifiable record of transactions and data.[230]

B. *Blockchain for Environmental Monitoring and Industry Optimization*

Blockchain can work to accelerate climate centric action in areas such as transparency for environmental monitoring, climate financing, and clean energy markets.[231] Combining the concept of blockchain networks

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[222] *Id.*
[223] *Id.*
[224] *Id.*
[225] *Make Crypto Green Again*, CRYPTO CLIMATE ACCORD, https://cryptoclimate.org/ [https://perma.cc/BL6V-NRGF] (last visited Nov. 13, 2022).
[226] *Id.*
[227] U.N. ENV'T PROGRAMME, *supra* note 99.
[228] *Id.*
[229] *Id.*
[230] *See id.*
[231] *Id.*

with smart cities, additional considerations arise in setting forward this technology in a low cost and high-efficiency manner.[232] The city of Miami is already taking advantage of this technology by partnering with the French company Planetwatch, which has developed different types of sensors to be used in conjunction with the Algorand blockchain network.[233] The mayor of Miami attests that "when linked into a network, they will benefit residents and city officials by analyzing where pollution levels are the highest."[234] The sensors will record this data on the Algorand blockchain, making the information tamperproof and permanently, publicly accessible in real time on a carbon-negative blockchain network.[235] This domestic example displays the value of transparency in networks; with the right type of technology deployed, any organization or municipality can accurately track any type of environmentally relevant features.[236] Policy surrounding deployment of technology of this nature could become as particularized as to subsidize environmental sensors to monitor temperature and humidity of concrete.[237]

Aside from tracking, blockchain-based platforms like CarbonX work to turn reductions in greenhouse gas emissions into a cryptocurrency to be bought and sold, providing incentives for making more sustainable choices.[238] Publicly accessible information on different organizations' sustainability practices could provide an enormous incentive, along with the cryptocurrency itself, to encourage sustainability across different industries. Other projects such as the Carbon Utility Token ("CUT") are looking towards the same goals of transparency and sustainability, working to provide a network to help corporations manage their carbon allowances.[239] In this system, each purchased CUT provides funding for

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[232] *See* Yanfeng Jiang & Wenyu Zheng, *Coupling Mechanism of Green Building Industry Innovation Ecosystem Based on Blockchain Smart City*, J. OF CLEANER PROD., July 20, 2021, at 1, 1.

[233] Mark Brennan, *Miami Becomes First U.S. City to Deploy Air Quality Monitoring Network Based on Algorand (ALGO) Blockchain*, CRYPTO BASIC (Dec. 2, 2021), https://thecryptobasic.com/2021/12/02/miami-becomes-first-main-u-s-city-to-deploy-air-quality-monitoring-network-based-on-algorand-algo-blockchain/ [https://perma.cc/EM58-CBZ4].

[234] *Id.*

[235] *Id.*

[236] *See* U.N. NEWS, *supra* note 215.

[237] Steven McKie, *Permaculture and Crypto: Green with No Envy*, MEDIUM (Aug. 5, 2021), https://medium.com/amentum/permaculture-and-crypto-green-with-no-envy-525af61ab884 [https://perma.cc/93G6-G8GM].

[238] *CarbonX*, https://positiveblockchain.io/database/carbonx/ [https://perma.cc/TD4B-QW37] (last visited Nov. 13, 2022).

[239] Stonberg, *supra* note 160.

investments in carbon capture and offsetting programs to work towards crypto carbon neutrality.[240]

C. Supply Chain Sustainability Goals

Arguably the industry most primed for disruption by blockchain technology is the global supply chain. Consumers and investors are more interested in corporate transparency than ever before, and generally companies are taking notice of these interests and prioritizing environmental, social, and governance policies.[241] Regulations, such as the European Green Deal, requires enhanced due diligence in sourcing materials in supply chains, and the Sustainability Accounting Standards Board suggests companies perform audits with product vendors.[242] With blockchain, industries engaged in supply chains can track materials throughout the shipping process with real-time verification and guaranteed certainty.[243] This can help companies verify that they source goods from sustainable sources and suppliers, as well as assist in reducing carbon footprints, making ESG disclosures more accurate, efficient, and sustainable due to the visibility of blockchain networks.[244] New U.S. regulations imposing enhanced due diligence requirements of food distributors could feasibly work to push industry leaders towards blockchain technology in order to remain in compliance.[245] Prior to this legislation, corporations like Walmart and Nestle had already begun efforts to implement blockchain technology for food tracking throughout their supply chains, regulations such as the proposed Food Safety Modernization Act for Food Traceability could work to push the rest of the industry in the same direction.[246]

Managing all information associated with supply chain production and distribution is generally a challenge already, as seen in the past few years, during periods of global strife, supply chains may be subject to

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[240] *Id.*
[241] Guy Flynn, Lin Pang, Rodolfo Araujo, Steven S. McNew & Bill Post, *Is Blockchain the Key to a More ESG-Compliant Supply Chain?*, DLA PIPER (Jan. 26, 2022), https://www.dlapiper.com/en/us/insights/publications/2022/1/is-blockchain-the-key-to-a-more-esg-compliant-supply-chain/ [https://perma.cc/4SDP-F4ZG].
[242] *Id.*
[243] *Id.*
[244] *Id.*
[245] Suman Bhattacharyya, *FDA Official Says New Rule Could Boost Blockchain-Based Food Tracking*, WALL ST. J. (Feb. 1, 2022, 5:30 AM), https://www.wsj.com/articles/fda-official-says-new-rule-could-boost-blockchain-based-food-tracking-11643711402?mod=djemCIO [https://perma.cc/8SJ2-V8GZ].
[246] *Id.*

serious disruption.[247] Not only would blockchain benefit environmental goals directly, but it would also work to strengthen global supply chains through its powerful cryptographic encryption and decentralized structure.[248] Given that most supply chain logistics networks run on paper-based record-keeping systems, every company interacting with a product must retain a manual record.[249] This paper-based system is subject to inconsistencies, ease of forgery, and long wait times, which may leave products stuck in ports waiting for a paper bill of lading to arrive.[250] Switching to an entirely digital system based on blockchain technology can work to remove these inefficiencies with instant document verification, document transmission, and real-time verification, all the while retaining a level of security and immutability far exceeding that of a paper-based system. Industry attention towards blockchain comes in no small part, with companies such as UPS, Penske, and Salesforce forming the blockchain in Transport Alliance, with over five hundred members in twenty-five countries.[251] Other major industry leaders such as Maersk and IBM collaborated to create the TradeLens platform using blockchain technology aiming to establish greater collaboration and trust within the global shipping industry.[252]

On a smaller level, some private blockchain-based projects such as Mattereum are emerging to address industry efficiency issues and are working to revolutionize supply chains through tracking production of materials as well as assets like carbon credits.[253] A reality in this space, however, is that these types of solutions, such as incentivizing sustainability practices, received attention for years past.[254] The concern is whether, or more aptly when, these initiatives will reach scale and widespread adoption.[255] But as already addressed, this is already occurring in the blockchain industry and the traditional world.[256] Tata Steel, a major Indian steel producer stepped into the blockchain space along with HSBC,

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[247] Eric L. Sophir, Eugenia Wang & Kathleen E. Wegryzn, *Blockchain for Digital Logistics and Smart Warehouses*, FOLEY & GARDNER LLP (Feb. 10, 2022), https://www.foley.com/en/insights/publications/2022/02/blockchain-for-digital-logistics-smart-warehouses [https://perma.cc/4ZGE-8SYT].
[248] *Id.*; *see* Flynn et al., *supra* note 241.
[249] Sophir et al., *supra* note 247.
[250] *Id.*
[251] *Id.*
[252] *Id.*
[253] McKie, *supra* note 237.
[254] *See* BITCOIN CLEAN ENERGY INITIATIVE MEMORANDUM, *supra* note 183, at 4.
[255] *Blockchain Strategy*, *supra* note 96.
[256] Flynn et al., *supra* note 241.

transacting using smart contracts to enable an end-to-end paperless deal entirely on the Contour blockchain network.[257] The Contour blockchain network enables connection between transacting parties virtually with the security and trust unique to blockchain networks; presenting the opportunity to both digitize and automate traditional legal documents in international deals, such as a bill of lading between a bank and the respective parties to a given transaction.[258] Utilizing a decentralized blockchain and the benefits inherent to it allows for all legal aspects associated with international trade deals to be run through automated smart contracts, and allows real-time verification of information relevant to the transaction at every step of the process.[259] Blockchain technology in supply chains and international transactions substantially reduces the time required for document negotiation and bank transactions from weeks to a matter of days.[260] With this massive improvement in efficiency, the associated energy costs saved from slashing contract settlement throughout the shipping process to only a few days would be enormous. Widespread adoption in supply automation through this technology would push the industry further towards environmental sustainability goals and drastically optimize supply chain efficiency.

CONCLUSION

While still nascent, blockchain innovation is no longer on its way, it is already here. This technology stands to revolutionize the way in which traditional industries operate and improve efficiency and corporate transparency by orders of magnitude. While world leaders still squabble over the potential environmental concerns set forth by the first ever iterations of blockchain technology, the industry has evolved towards environmental sustainability in various fronts.[261] However, the

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[257] Aditi Divekar, *A Global First: Tata Steel-HSBC Do Blockchain-Enabled Paperless Trade Deal*, BUS. STANDARD (Apr. 21, 2021, 11:30 PM), https://www.business-standard.com/article/companies/a-global-first-tata-steel-hsbc-do-blockchain-enabled-paperless-trade-deal-121042100658_1.html [https://perma.cc/DU6E-FQPA]; *see* CONTOUR, https://contour.network/ [https://perma.cc/J4ZR-EFXN] (last visited Nov. 13, 2022).

[258] Gabrielle Vilda, *HSBC and Tata Steel Successfully Execute a Blockchain-Enabled, Paperless Trade Transaction—a Global First for the Steel Industry*, TRADE FIN. GLOB. (Apr. 22, 2021), https://www.tradefinanceglobal.com/wire/hsbc-and-tata-steel-successfully-execute-a-blockchain-enabled-paperless-trade-transaction-a-global-first-for-the-steel-industry/ [https://perma.cc/M5E2-HLQ4].

[259] *Id.*

[260] *Id.*

[261] *See* U.N. ENV'T PROGRAMME, *supra* note 99.

industry is not without its environmental shortcomings, and presently the largest blockchain networks stand to provide substantial financial benefits to those taking part while also posing significant environmental risks.[262] This Note sets out to outline the major environmental considerations most prevalent to the federal discussion of blockchain technology, laying out the international conversation around the technology and the patchwork approach to regulation that continues to build in the United States. Without federal guidance based on due diligence into the industry, this patchwork will continue to emerge without any universal attention to the potential environmental costs associated. Not only can federal guidance provide a solution that stands to benefit both blockchain and the renewable energy industry, but also work to facilitate blockchain innovation in the United States in manners attendant to achieving environmental sustainability goals. Without U.S. lawmakers moving past irrational fears of the industry, they will continue to fall behind on the international level on blockchain-based development.

[262] *Id.*