2024

Win-Win Environmental Regulations for Crypto Mining: Developing a Regulatory Program That Reduces Environmental Harm and Promotes Innovation and Competition

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BRADLEY R. FINNEY*

Abstract: The crypto space is a rapidly growing industry with a rapidly growing carbon footprint. The industry's expanding energy use has sparked a vigorous debate over whether and how best to regulate crypto mining's environmental effects. The Biden Administration and many members of Congress have studied the industry's environmental impact and concluded that there should be environmental regulations for the industry. Regulation, however, faces an obstacle in the form of concern that regulation may unduly stifle innovation and competition within the industry. This is a major reason why Congress has yet to enact environmental regulations for crypto mining.

This Article proposes a win-win regulatory approach that would reduce crypto mining's environmental harms while also promoting, rather than stifling, competition and innovation. The Article proposes applying the Porter Hypothesis, a well-known economic theory in environmental law scholarship, to the problem of environmental harm caused by crypto mining. The Porter Hypothesis calls for a consultative, flexible approach to environmental regulation that involves input from the industry, focuses on reducing pollution at its source instead of mitigating its effects after the fact, and provides the industry flexibility by setting emission limits and using market incentives, but not prescribing the technological means, to meet them.

Applied to crypto mining, the Porter Hypothesis suggests regulations that use a market incentive—like a pollution tax or a cap-and-trade program—to encourage crypto miners to reduce their pollution at its source, without mandating the use of a particular technology. The program should also provide funding for pilot projects, use phase-in periods and realistic deadlines, as well as require policymakers to monitor and publish data about individual miners' energy usage and greenhouse gas emissions. This Article is the first to propose a regulatory program of environmental regulations for the industry, the first to apply the Porter Hypothesis to crypto mining, and the first to propose a regulatory approach that

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offers a win-win solution to overcome political opposition to regulating the environmental harms of crypto mining.

INTRODUCTION

The rapid rise in the use of cryptocurrencies (cryptos) by individuals, businesses, and large financial institutions has captured the global economy's attention. The attractiveness of cryptos as an alternative to traditional currencies is transforming financial and business landscapes.[1] Even after the value of cryptos slid from their all-time highs, it appears the industry is here to stay.[2]

The rising popularity and growth of cryptos, as well as the rise of the United States as the largest locus of crypto mining activity in the world, has increased the level of scrutiny from the United States government regarding the industry's environmental harms.[3] Crypto mining—especially Bitcoin mining—causes serious environmental harm because it consumes incredible amounts of energy to perform the computer operations that "mine" crypto—energy largely produced by fossil fuels.[4] The use and extraction of fossil fuels takes an enormous toll on ecosystems, contributes to climate change, and harms human health.[5] Further, the significant amount of energy crypto mining uses is a purposeful security feature of Bitcoin, not an accidental cost.[6] There-

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[1] *See, e.g.*, Imane Adel, *How Blockchain Is Transforming the Entire Financial Services Industry*, FORBES (June 7, 2023), https://www.forbes.com/sites/forbestechcouncil/2023/06/07/how-blockchain-is-transforming-the-entire-financial-services-industry/?sh=5cd894732753 [https://perma.cc/6UN4-HV8M] (exploring the disruptions in the traditional business thought processes caused by crypto).

[2] *See, e.g.*, Joe Light, *Crypto Is Staging a Major Rebound. How It Survived a $3 Trillion Crash.*, BARRON'S, https://www.barrons.com/articles/bitcoin-crypto-prices-bubble-recovery-3f109a05 [https://perma.cc/NW62-34AE] (May 25, 2023) (explaining how crypto is able to survive harsh financial winters and bounce back).

[3] *See, e.g.*, Eliza Gkritsi & Nikhilesh De, *White House Calls for Crypto Mining Standards to Minimize Environmental Impact*, YAHOO! FIN., https://finance.yahoo.com/news/crypto-mining-energy-implications-further-141116522.html?guccounter=1 [https://perma.cc/RHP2-52VL] (Sept. 8, 2022) (pointing towards the White House's call for crypto regulation). *See generally, e.g.*, *Building a Stronger Financial System: Opportunities of a Central Bank Digital Currency: Hearing Before the Subcomm. on Econ. Pol'y of the S. Comm. on Banking, Hous. & Urb. Affs.*, 117th Cong. (2022) (statement of Sen. Elizabeth Warren, Chair, Econ. Pol'y) (reflecting congressional movement toward crypto regulation).

[4] 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/CH7Z-GRRP].

[5] *Id.*; *Greenhouse Gases: What Are the Trends in Greenhouse Gas Emissions and Concentrations and Their Impacts on Human Health and the Environment?*, EPA, https://www.epa.gov/report-environment/greenhouse-gases [https://perma.cc/J338-E3MQ] (July 14, 2023).

[6] *See* E. Napoletano, *Proof of Work Explained*, FORBES ADVISOR, https://www.forbes.com/advisor/investing/cryptocurrency/proof-of-work/ [https://perma.cc/3PVD-4QNU] (Jan. 3, 2024) (explaining that the energy consumption in certain crypto systems is a byproduct of intentional security measures to avoid double spending and other breaches).

fore, without regulation, it is highly unlikely that the industry will resolve these issues on its own.

Because crypto mining only consumes fossil-fuel energy, rather than directly emitting pollutants into the air, the Clean Air Act (CAA) does not regulate it.[7] Thus, crypto mining is driving increases in fossil-fuel energy production and emissions without being directly subject to environmental regulations. Therefore, the United States government and its people have an interest in promulgating specific environmental regulations for crypto mining to close this regulatory gap.

For these reasons, the environmental harm caused by such mining has prompted considerable study, comment, and activity by the White House and Congress.[8] President Biden issued an executive order urging Congress to consider legislation addressing this issue.[9] Several members of Congress proposed bills relating to crypto's environmental harms.[10] None of those bills, however, proposes actual environmental regulations for crypto.[11] Instead, they would give regulatory power to a particular agency and direct an agency to start collecting energy use and pollution data of individual mining companies.[12] And most recently, the Biden Administration proposed a tax on crypto miners that would require them to pay a tax of thirty percent of the cost of all electricity they use to mine crypto—regardless of the fuel source used to produce the electricity.[13]

But although these officials have recognized a need to regulate and reduce crypto miners' energy usage and environmental harms, many, including some of those who recognize the need to regulate, have expressed concern that regu-

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[7] *See* Jasmine N. Story, Note, *Cloud Computing and the NSA: The Carbon Footprint of the Secret Servers*, 9 PITT. J. ENV'T & PUB. HEALTH L. 33, 44–45 (2014) (explaining that the Clean Air Act (CAA) applies only to energy producers, not those demanding the energy).

[8] *See supra* note 3 and accompanying text (giving an overview of the government's response to the growing issue of crypto energy consumption).

[9] Press Release, The White House, President Biden to Sign Executive Order on Ensuring Responsible Development of Digital Assets (Mar. 9, 2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/09/fact-sheet-president-biden-to-sign-executive-order-on-ensuring-responsible-innovation-in-digital-assets/ [https://perma.cc/2XRX-8T3X].

[10] *See infra* note 145 and accompanying text (illustrating the various bills currently in Congress addressing the issue).

[11] *See infra* note 145 and accompanying text (showing that Congress has not yet offered legislative solutions to address the environmental impact of crypto).

[12] *See, e.g.*, Lummis-Gillibrand Responsible Financial Innovation Act, S. 4356, 117th Cong. § 403 (2022) (empowering the Securities and Exchange Commission (SEC) and Commodity Futures Trading Commission (CFTC) to regulate crypto markets and requiring energy reports from the Federal Energy Regulatory Commission).

[13] *The DAME Tax: Making Cryptominers Pay for Costs They Impose on Others*, THE WHITE HOUSE (May 2, 2023), https://www.whitehouse.gov/cea/written-materials/2023/05/02/cost-of-cryptomining-dame-tax/ [https://perma.cc/Y7LT-BJU2].

lation would stifle innovation and competition.[14] The industry itself also has opposed regulations on these grounds.[15] Largely due to these concerns, Congress has not yet enacted environmental regulations for crypto miners.[16] Until this roadblock is overcome, there are dim prospects for regulating the environmental harms caused by the crypto industry.

At the same time, despite a growing public and political awareness of the significant harms caused by crypto miners, there has been sparse academic legal analysis focused on how to use regulation to reduce miners' sizable energy consumption and use of fossil fuels. Scientists who research the energy consumption of cryptos seem to agree that crypto mining is energy-intensive and inefficient, and that the practice could and should be improved.[17] Legal scholarship, however, has yet to consider how policymakers can incentivize a transition to more efficient and environmentally friendly mining.[18]

This Article proffers a way around the legislative roadblock, and fills the gap in legal scholarship, by proposing a regulatory program that balances the twin goals of reducing environmental harms while furthering innovation and competition within the industry.[19] The proposal is to use the Porter Hypothesis (PH) as the guiding principle for a program of environmental regulation of crypto mining.

The PH is an economic theory arguing that properly designed regulations can encourage innovation and competition within the regulated industry as a means to achieving targeted reductions in environmental damage.[20] The PH states that regulation can induce technological and process innovations when industries have, or are forced to develop, the willingness and capacity to inno-

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[14] Brady Dale, *Updated Lummis-Gillibrand Bill Adds Momentum for New Crypto Legislation*, AXIOS (July 13, 2023), https://www.axios.com/2023/07/13/senators-lummis-gillibrand-crypto-bill [https://perma.cc/XJ26-DEC3] (revealing that both Congresswomen Gillibrand and Lummis stress the importance of regulation that does not choke the industry).

[15] *See* Tory Newmyer, *Crypto Finds a Bright Spot in a Stormy Summer: Congress*, WASH. POST (Aug. 7, 2022), https://www.washingtonpost.com/business/2022/08/07/crypto-lobbying-surges/ [https://perma.cc/5HB5-8JFD] (depicting the crypto industry's resistance to regulation).

[16] *See infra* note 148 and accompanying text (noting that none of the legislative measures for regulation has actually passed through Congress).

[17] *See, e.g.*, Audrey Carroll, Note, *The Other Side of the (Bit)Coin: Solutions for the United States to Mitigate the Energy Consumption of Cryptocurrency*, 12 GEO. WASH. J. ENERGY & ENV'T L. 53, 56 (2021) (exploring various ways to reduce the environmental footprint of cryptocurrency).

[18] *See id.* (failing to explore regulatory solutions and only analyzing solutions from the industry's side).

[19] *See infra* Part IV.

[20] *See* STEFAN AMBEC, MARK A. COHEN, STEWART ELGIE & PAUL LANOIE, RES. FOR THE FUTURE, THE PORTER HYPOTHESIS AT 20: CAN ENVIRONMENTAL REGULATION ENHANCE INNOVATION AND COMPETITIVENESS? 2–3 (2011), https://media.rff.org/documents/RFF-DP-11-01.pdf [https://perma.cc/JV6W-Z7CH] (providing an introduction to the Porter Hypothesis (PH)).

vate.[21] The theory focuses on targeting increases in efficiency of resource use, like electricity or fuels, while allowing companies to innovate to hit those targets.[22] It also proposes consulting the industry in the regulatory process and setting targets with phased-in deadlines and sufficient time to innovate in order to meet them.[23]

When these principles are instituted through regulations, these innovations frequently result in financial net positives for companies as the added revenues, or costs saved, are often greater than the compliance costs.[24] Further, making the industry more environmentally friendly itself improves competitiveness by satisfying growing customer demand for "green" products.[25]

The Article applies these principles of the PH to crypto to construct a broad regulatory program tailored to crypto mining based on the unique characteristics of the industry and gives examples of specific regulatory mechanisms that should be implemented for crypto miners.[26] Environmental regulation for crypto mining should set greenhouse gas (GhG) emission limits that crypto miners must meet, thus incentivizing miners to innovate to solve, or at least reduce, the industry's environmental problems. To begin with, the regulatory process should be knowledgeable, consultative, and cooperative. The resulting regulations should give the industry technological flexibility to meet standards through the use of one of two market incentives: a pollution tax or a cap-and-trade program. They should also focus on encouraging product and process changes that reduce or prevent the pollution rather than secondary treatments that mitigate some of the effects of the pollution after the pollution has occurred. Further, the regulations should fund research and pilot projects to help miners find ways to reduce mining's environmental harms. To promote successful implementation of the regulations, there should be a phase-in period, realistic compliance deadlines, data-gathering and dissemination to track miners' energy use and GhG emissions, and a precommitment to regulatory stability by keeping the regulations in place and unchanged for at least five years.

This approach would curb environmental degradation while also encouraging innovation and spurring competition, and it would do so without banning specific types of crypto mining. Overall, this kind of increased innovation and

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[21] *See* Michael E. Porter & Claas van der Linde, *Toward a New Conception of the Environment-Competitiveness Relationship*, 9 J. ECON. PERSPS. 97, 98 (1995) (arguing that properly created environmental regulations will stimulate innovation).

[22] *See* Michael E. Porter & Claas van der Linde, *Green and Competitive: Ending the Stalemate*, HARV. BUS. REV., Sept.–Oct. 1995, at 120, 122 (arguing that pollution is a physical symptom of resource inefficiency).

[23] *Id.* at 124.

[24] Porter & van der Linde, *supra* note 21, at 98.

[25] *Id.* at 104 (discussing burgeoning consumer demand for "green" products).

[26] *See infra* Part IV.

competition within the crypto mining industry would likely result in reduced energy usage, less GhG emissions, an improved environment, and healthier people. Ultimately, then, the PH shows a way to regulate that would reduce environmental harm while also promoting innovation and competition.[27] This regulatory program would present legislators with a win-win solution, thus making it easier to garner enough support for such legislation.

Additionally, this Article's proposed regulatory program for crypto regulations could demonstrate the benefits of a PH-based approach to environmental regulations. Once the proposed regulatory program is proven to reduce environmental harms while still encouraging innovation and competition, other environmental regulations could mimic this approach.

This Article proceeds in four parts. Part I explains how the technology behind many of the major cryptos, including Bitcoin, causes environmental harm, primarily through massive and increasing energy consumption.[28] Part II describes how the President, Congress, and the Environmental Protection Agency (EPA) have been investigating and have begun advancing proposals to regulate the environmental harms caused by crypto.[29] This Part also examines crypto-industry pushback in response and explains how a primary roadblock to regulatory efforts is the concern of unduly hampering innovation and competition in the industry.[30] Part III explains the PH, its principles, and the expected benefits flowing from implementing an environmental regulatory program for crypto mining that is faithful to those principles.[31] Part IV then applies the PH's principles to environmental regulation of the crypto industry.[32] It proposes principles for framing environmental regulation for crypto mining and examples of specific regulatory mechanisms tailored to crypto mining. These proposed mechanisms utilize the perspectives gained from the PH to find ways to limit the severe harm to the environment caused by crypto mining while also promoting innovation and competition in the crypto industry.

I. Crypto Mining and Its Environmental Harms

This Part discusses the environmental impact of cryptocurrency, all of which stems from its large energy consumption.[33] Section A gives an overview

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[27] Porter & van der Linde, *supra* note 21, at 98.
[28] *See infra* notes 33–116 and accompanying text.
[29] *See infra* notes 117–184 and accompanying text.
[30] *See infra* notes 117–184 and accompanying text.
[31] *See infra* notes 185–286 and accompanying text.
[32] *See infra* notes 287–516 and accompanying text.
[33] *See infra notes* 36–116 and accompanying text.

of what cryptocurrency is, how it works, and how it requires so much energy.[34] Section B then explores how that energy usage impacts the environment.[35]

A. Technological Origins of Crypto's Intensive Energy Usage

A crypto is a virtual medium of exchange that exists only electronically.[36] It does not have a physical counterpart, such as a coin or dollar bill.[37] Today, cryptos are growing in popularity and are used regularly to buy food, movie tickets, and video games,[38] as well as pay employees.[39] As of February 2024, the market capitalization[40] of the largest ten cryptos was $1.67 trillion.[41] As of the same date, the market capitalization of Bitcoin alone was over $1 trillion.[42]

Crypto users value cryptos because they can be decentralized,[43] are trustless,[44] and are largely anonymous.[45] Consensus mechanisms were the technological innovation that allowed for the existence of currencies without central intermediaries, such as banks.[46] This technological innovation acted as the so-

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[34] *See infra notes* 36–82 and accompanying text.

[35] *See infra notes* 83–116 and accompanying text.

[36] *See Digital Assets*, INTERNAL REVENUE SERV., https://www.irs.gov/businesses/small-businesses-self-employed/digital-assets [https://perma.cc/976H-3MPB] (comparing and contrasting "digital assets" with hard currency).

[37] *Id.*

[38] *E.g.*, Cheyenne DeVon, *From Whole Foods to GameStop, Here Are 5 Retailers That Accept Crypto—But There's a Catch*, CNBC, https://www.cnbc.com/2022/10/14/whole-foods-gamestop-places-to-spend-crypto.html [https://perma.cc/H3AG-RH3X] (Oct. 15, 2022).

[39] *See* Jessica Post & David McCarville, *Is It Time to Start Paying Your Employees in Cryptocurrency?*, PHX. BUS. J. (May 24, 2022), https://www.bizjournals.com/phoenix/news/2022/05/24/is-it-time-to-start-paying-in-cryptocurrency.htmls [https://perma.cc/6WNX-DL6A] (explaining that highly paid professionals—like professional athletes—have begun receiving payment in the form of cryptocurrency).

[40] *See What Is Market Cap?*, COINBASE, https://www.coinbase.com/learn/crypto-basics/what-is-market-cap [https://perma.cc/K37Y-R85Y] (explaining that the market capitalization for a crypto is "calculated by multiplying the number of coins in circulation by the current market price of a single coin").

[41] *Top Cryptos by Market Cap*, YAHOO! FIN., https://finance.yahoo.com/u/yahoo-finance/watchlists/crypto-top-market-cap/ [https://perma.cc/FY7E-V67J].

[42] *Id.*

[43] Igor Makarov & Antoinette Schoar, *Cryptocurrencies and Decentralized Finance (DeFi)*, BROOKINGS PAPERS ON ECON. ACTIVITY, Spring 2022, at 141, 142. "Decentralized" means that anyone with enough money and an internet connection can buy and use cryptos. *Id.* Further, the transactions of cryptos using the "Proof of Work" (PoW) system are recorded on a blockchain ledger, which is considered decentralized because instead of a central authority—like a bank or government—holding and maintaining the ledger, the blockchain ledger is stored on every computer that is connected to the network. *Id.*

[44] *Id.* at 146. Instead of using trust to complete transactions, the system relies largely on automation to ensure that transactions are accurate and nonfraudulent. *Id.*

[45] *Id.* at 142.

[46] *What Is Consensus? A Beginner's Guide*, CRYPTO.COM (May 13, 2022), https://crypto.com/university/consensus-mechanisms-explained [https://perma.cc/ZFQ3-FEB5]. A lack of a central in-

lution to the problem of trying to have a trustless currency with records that could be updated in real time.[47] Further, consensus mechanisms are the reason that crypto owners and transactions in cryptos are largely anonymous.[48] Thus, consensus mechanisms were the critical technological advancement of crypto and are a primary reason for crypto's popularity with users and investors.[49]

Consensus mechanisms verify that each transaction is secure and trustworthy.[50] There are several different types of consensus mechanisms, but the most commonly used are Proof of Work (PoW)[51] and Proof of Stake (PoS).[52]

PoW cryptos use a combination of cryptography and mathematics to verify and process new groups of transactions used by that crypto.[53] Under a PoW system, computers connected to the network, referred to as "miners," are rewarded with newly minted crypto coins if they are the first miner to correctly verify a new group of transactions and correctly guess[54] a complicated math problem.[55] The winning miner records the new batch of transactions into the

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termediary means that, unlike the U.S. dollar and the currencies of other countries, there is no authority, like a government, backing or producing coins and policing whether those coins are double-spent. *Id.*

[47] *See* Francisco José de Haro-Olmo, Ángel Jesús Varela-Vaca & José Antonio Álvarez-Bermejo, *Blockchain from the Perspective of Privacy and Anonymisation: A Systematic Literature Review*, SENSORS, Dec. 2020, at 1, 4–6 (describing the consensus mechanism's role in decentralizing and diversifying the blockchain's ledger).

[48] *See id.* at 4–6, 13–15 (discussing the specific technological requirements present in blockchain technology allowing for user privacy).

[49] *What Is Consensus? A Beginner's Guide*, *supra* note 46.

[50] *Id.*

[51] *See* Napoletano, *supra* note 6 (explaining that most cryptos use PoW as their consensus mechanism, including Bitcoin, Litecoin, and Dogecoin). Given the popularity of Bitcoin, this Section will discuss the details of Bitcoin's PoW system, but it should be noted that cryptos using PoW can vary slightly as to the specific way in which one mines them. *See What Are the Different Ways to Mine Cryptocurrency?*, COINTELEGRAPH, https://cointelegraph.com/learn/what-are-the-different-ways-to-mine-cryptocurrency [https://perma.cc/X4GK-4AEM].

[52] *What Are the Different Ways to Mine Cryptocurrency?*, *supra* note 51.

[53] *Id.* Cryptography is defined as "the practice of developing and using coded algorithms to protect and obscure transmitted information so that it may only be read by those with the permission and ability to decrypt it." *What Is Cryptography?*, IBM, https://www.ibm.com/topics/cryptography [https://perma.cc/H6KE-4VC3].

[54] *See* Jeffrey C. Thomson, Note, *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, 84–86 (2020) (explaining that miners guess quintillions of numbers per second to try to get the right answer to acquire the block); *see also* Arne Bochem & Benjamin Leiding, *Rechained: Sybil-Resistant Distributed Identities for the Internet of Things and Mobile Ad Hoc Networks*, SENSORS, May 2021, at 3–4 (explaining the method of "mining" used by PoWs, in which the blockchain rewards the first user to solve the mathematical equation); Makarov & Schoar, *supra* note 43, at 147 (same).

[55] *What Is Consensus? A Beginner's Guide*, *supra* note 46. Once a miner verifies the new batch of transactions, that miner submits its results to the network. Napotelano, *supra* note 6. If the winning

blockchain ledger, where they become permanent.[56] PoW consensus mechanisms are designed so that a new set of transactions is mined approximately every ten minutes, which means that a miner successfully solves the math equation approximately every ten minutes.[57]

Further, to avoid manipulation of the ledger, the system is designed so that the equations become increasingly complex as more computing power joins the system.[58] This, in turn, means that a continually increasing amount of computing power is required to mine PoW cryptos, like Bitcoin, which means a continually increasing amount of energy is consumed mining it.[59]

When creating Bitcoin's PoW consensus mechanism, the owner intentionally provided substantial amounts of Bitcoin to miners to attract fierce competition.[60] This is because competition prevents tampering, self-dealing, and fraud.[61] This tactic worked in the sense that there is a now robust market of crypto miners and there has never been a successful "51% attack" on the Bitcoin network.[62]

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miner's work gets a majority vote from the other miners that each transaction is accurate, the new group of transactions are entered into the Bitcoin ledger and are considered "mined." *Id.*

[56] Lyle Daly, *What Is Proof of Work (PoW) in Crypto?*, MOTLEY FOOL, https://www.fool.com/terms/p/proof-of-work/#:~:text=The%20proof%2Dof%2Dwork%20algorithm,too%20slowly%2C%20they%20get%20easier [https://perma.cc/2FLB-BJJR] (Nov. 17, 2023).

[57] *Id.*

[58] Napotelano, *supra* note 6; MacKenzie Sigalos, *It Just Got Harder and Less Profitable to Mine for Bitcoin as Algorithm Adjusts*, CNBC, https://www.cnbc.com/2021/08/12/bitcoin-mining-becomes-more-difficult-as-algorithm-adjusts.html [https://perma.cc/K93T-KEH9] (Aug. 13, 2021); Press Release, The White House, Climate and Energy Implications of Crypto-Assets in the United States (Sept. 8, 2022), https://www.whitehouse.gov/ostp/news-updates/2022/09/08/fact-sheet-climate-and-energy-implications-of-crypto-assets-in-the-united-states/ [https://perma.cc/ZY4Q-2NQ8].

[59] Sigalos, *supra* note 58; Press Release, *supra* note 58.

[60] *See generally* SATOSHI NAKAMOTO, BITCOIN: A PEER-TO-PEER ELECTRONIC CASH SYSTEM (2018), https://bitcoin.org/bitcoin.pdf [https://perma.cc/UZ43-TPFM] (explaining the incentive system for starting a new cryptocurrency and specifically the system Bitcoin uses).

[61] *See* Shijie Lin, *Proof of Work vs. Proof of Stake in Cryptocurrency*, 39 HIGHLIGHTS SCI., ENG'G & TECH. 953, 956–57 (2023) (explaining that every user within a network acts as a check against an attacker trying to defraud the blockchain, such that an attack would need more computing power than the millions of users in the blockchain combined).

[62] Salomon Kisters, *Has There Ever Been a 51% Attack on Bitcoin?*, ORIGINSTAMP (Jan. 24, 2023), https://originstamp.com/blog/has-there-ever-been-a-51-attack-on-bitcoin/ [https://perma.cc/B8HR-FBAX]. Because a PoW ledger is collectively maintained and voted on by the network, and because anyone with a computer can join the network, there is a risk of a malicious attack by someone operating enough computers to constitute a majority on the network—a "51% attack." Jake Frankenfield, *51% Attack: Definition, Who Is at Risk, Example, and Cost*, INVESTOPEDIA, https://www.investopedia.com/terms/1/51-attack.asp [https://perma.cc/Y532-NCHV] (June 7, 2023). A 51% attack occurs when a miner, or a group of miners, controls more than half of a PoW network's computing power. *Id.* By gaining this majority control, the miner can use its power for nefarious purposes to "reroute the priority of new transactions being computed, and even reverse some of [its] own past transaction records (an issue called 'double spending') by altering the data embedded in the block-

Specifically, because of the substantial sums awarded to winning miners, competition among miners is fierce and many miners compete.[63] In 2022 alone, winning Bitcoin miners won over nine billion dollars worth of Bitcoin.[64] This has attracted approximately one million miners to the Bitcoin network.[65] Due to its hypercompetitive nature, crypto mining currently operates by utilizing large "climate-controlled facilities" with thousands of mining computers that are running constantly.[66]

Also, PoW mechanisms reward speed in solving the equations, meaning that miners must devote ever-increasing amounts of computing power to the mining arms race.[67] Increased computing power directly translates to increased energy consumption.[68]

There are alternative consensus mechanisms for verifying ledgers and processing transactions that are much less energy-intensive,[69] most notably PoS.[70] PoS mechanisms verify transactions through users who have "staked"

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chain." Nicholas Rossolillo, *What Is a 51% Attack?*, MOTLEY FOOL, https://www.fool.com/terms/0-9/51-percent-attack/ [https://perma.cc/DLY4-R7GB] (Feb. 1, 2024).

[63] Lawrence Wintermeyer, *What Does the Future Hold for Bitcoin Mining?*, FORBES (Mar. 13, 2022), https://www.forbes.com/sites/lawrencewintermeyer/2022/03/13/what-does-the-future-hold-for-bitcoin-mining/?sh=5002c193e9aa [https://perma.cc/S7SF-3ZGQ].

[64] Damian Chmiel, *Why Bitcoin Miners Made $6 Billion Less in 2022?*, FIN. MAGNATES (May 1, 2023), https://www.financemagnates.com/cryptocurrency/why-bitcoin-miners-made-6-billion-less-in-2022/ [https://perma.cc/7QF7-G8DN].

[65] Cho, *supra* note 4.

[66] Jeremy Hinsdale, *Cryptocurrency's Dirty Secret: Energy Consumption,* COLUM. CLIMATE SCH. (May 4, 2022), https://news.climate.columbia.edu/2022/05/04/cryptocurrency-energy/ [https://perma.cc/P4RB-F74A].

[67] Carroll, *supra* note 17, at 56.

[68] Thomson, *supra* note 54, at 84–86.

[69] *See* Carroll, *supra* note 17, at 57 (explaining that alternative consensus mechanisms, like Proof of Stake (PoS), use 99% less energy than PoW); *see also* Colin Lacina, Opinion, *The Inevitable Failure of Proof-of-Stake Blockchains and Why a New Algorithm Is Needed*, COINTELEGRAPH (May 24, 2015), https://cointelegraph.com/news/the-inevitable-failure-of-proof-of-stake-blockchains-and-why-a-new-algorithm-is-needed [https://perma.cc/69JD-A4TE] (discussing alternative consensus mechanisms including Proof of Hodl, Proof of Use, and Proof of Minimum Aged Stake).

[70] *See The History and Evolution of Proof-of-Stake*, COINTELEGRAPH (Oct. 15, 2017), https://cointelegraph.com/news/the-history-and-evolution-of-proof-of-stake [https://perma.cc/6VBE-NY8U] (explaining the origins of PoS as an alternative to PoW and the issues that accompany PoS). PoS was created as a less energy-intensive alternative to PoW. *Id.* Under a PoS system, there is not a race to solve a complex mathematical problem. *What Is Proof of Stake?*, MCKINSEY & CO. (Jan. 3, 2023), https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-proof-of-stake [https://perma.cc/TFW7-7JXD]. Instead, the winning validator is chosen through a process called "staking." Jaime Catmull, *How Proof of Stake Is Expanding the Crypto World for Investors*, FORBES (Mar. 10, 2022), https://www.forbes.com/sites/jaimecatmull/2022/03/10/how-proof-of-stake-is-expanding-the-crypto-world-for-investors/?sh=731cf66e4547 [https://perma.cc/RW53-GTYL]. It is helpful to think of staking as buying lottery tickets—the greater number of lottery tickets purchased (or coins staked), the greater chance the owner has at winning. *See generally* CORRIE E. CLARK & HEATHER L. GREENLEY, CONG. RSCH. SERV., R45863, BITCOIN, BLOCKCHAIN, AND THE ENERGY SECTOR 24 (2019)

their coins so they can be verifiers of transactions on the network.[71] Ethereum is the most notable and the largest user of PoS,[72] but there are others as well.[73]

Bitcoin enthusiasts contend, however, that these alternatives are inferior consensus mechanisms—especially PoS. According to these detractors, PoS is more prone to dominance and manipulation by the entities and people that are early adopters[74] or own the most of that crypto.[75] They aver that there are more accessibility limitations under a PoS mechanism,[76] and, therefore, there is more likely to be a centralization of power among a wealthy few.[77] Indeed, within Ethereum, there is a lack of decentralization, especially as compared to Bitcoin and other PoW cryptos, because transactions have to go through a small set of verifiers, selected because of their large "stakes" in the coin.[78] The combination of these factors, the argument contends, is more likely to lead to a nefarious owner of a significant stake of the underlying crypto approving self-dealing or fraudulent transactions to enrich themselves.[79]

Because Bitcoin was the first popular crypto, is most widely used, and has many enthusiastic supporters, it will not be easy to simply ban PoW mining in favor of the less energy-intensive PoS mining. Further, even if such mining could be banned in the United States, a ban would likely cause many mining operations to simply move to another country, as when China banned crypto mining.[80] Although this might mitigate some of the localized environmental harms caused by crypto mining, many of the global environmental harms would still be felt in the United States, as would the negative impact on climate

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(summarizing the difference between PoW and PoS systems). Because there is not a race to solve a mathematical problem, PoS consumes 99% less energy than PoW. Carroll, *supra* note 17, at 57.

[71] CLARK & GREENLEY, *supra* note 70, at 24; *What Is Proof of Stake?*, *supra* note 70.

[72] CRYPTO CARBON RATINGS INST., THE MERGE—IMPLICATIONS ON THE ELECTRICITY CONSUMPTION AND CARBON FOOTPRINT OF THE ETHEREUM NETWORK 4–5 (2022). On September 15, 2022, Ethereum successfully switched from PoW to PoS mining. *Id.*

[73] *See* Makarov & Schoar, *supra* note 43, at 150–54 (discussing the advantages of a PoS system over a PoW system, including lower energy usage, and the cryptos that used PoS systems as of 2022).

[74] Rob Matheson, *Bitcoin Study: Period of Exclusivity Encourages Early Adopters*, MIT NEWS (July 13, 2017), https://news.mit.edu/2017/bitcoin-study-period-exclusivity-encourages-early-adopters-0713 [https://perma.cc/84G3-YKTX].

[75] Ben Gehmlich, *Ethereum Blockchain Security; Pros and Cons of PoS Solutions*, GIGSTER (Oct. 10, 2022), https://gigster.com/blog/pros-and-cons-of-pos-for-ethereum-security/ [https://perma.cc/38ZD-BHKL].

[76] *Id.*

[77] *Id.*

[78] *Id.*; Matheson, *supra* note 74.

[79] *See* Gehmlich, *supra* note 75 (explaining that in the unlikely scenario where coin ownership becomes too centralized, other security issues may arise).

[80] *See* Alun John, Samuel Shen & Tom Wilson, *China's Top Regulators Ban Crypto Trading and Mining, Sending Bitcoin Tumbling*, REUTERS (Sept. 24, 2021), https://www.reuters.com/world/china/china-central-bank-vows-crackdown-cryptocurrency-trading-2021-09-24/ [https://perma.cc/WLL9-BL5N] (discussing China's decision to crack down on crypto).

change.[81] For these reasons, this Article proposes a regulatory approach that does not ban PoW cryptos (or any other type of crypto or crypto mining), but instead seeks to allow the industry to innovate to reduce its environmental harms.[82]

B. Crypto's Intensive Energy Use Harms the Environment, Climate, and Human Health Through Enormous, and Increasing, Fossil Fuel Consumption

Because PoW crypto mining is so energy-intensive, and because most of that energy comes from fossil fuels, crypto mining causes serious environmental and climate damage.[83] Fossil fuels—such as coal and oil[84]— emit GhGs, which in turn degrade the environment, contribute to climate change, and harm human health.[85]

The energy consumption of PoW mining is enormous, and the environmental implications are far-reaching.[86] In PoW mining, it can take trillions of computer guesses to solve the math equation.[87] A University of Cambridge analysis estimated that Bitcoin mining alone consumes more electricity annually than many major countries, like Argentina.[88] PoW mining also exceeds the annual energy consumption of Google, Apple, Facebook, and Microsoft com-

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[81] *See Climate Change Impacts Are Increasing for Americans*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. (Nov. 14, 2023), https://www.noaa.gov/news-release/climate-change-impacts-are-increasing-for-americans#:~:text=Climate%20change%20is%20harming%20physical,damages%20are%20expected%20to%20accelerate [https://perma.cc/GQ27-TL5S] (explaining how the far-reaching impacts of global climate change affect Americans locally); *cf.* Lindsay Maizland, *China's Fight Against Climate Change and Environmental Degradation*, COUNCIL ON FOREIGN RELS., https://www.cfr.org/backgrounder/china-climate-change-policies-environmental-degradation [https://perma.cc/UR5T-MBVP] (May 19, 2021) (detailing the enormous role China plays in climate change and global emissions).

[82] *See infra* Part IV.

[83] *See, e.g.*, Carroll, *supra* note 17, at 53–54 (stating that Bitcoin produces as much carbon emissions as mid-sized countries); Thomson, *supra* note 54, at 85–86 (showing that Bitcoin's energy usage dwarfs that of technology companies, like Google); CLARK & GREENLEY, *supra* note 70, at 24 (explaining that global Bitcoin energy usage in 2019 matched that of 1% of the American electricity capacity).

[84] *Fossil*, ENERGY.GOV, https://www.energy.gov/fossil [https://perma.cc/VK3X-TGA7].

[85] *See The Causes of Climate Change*, NASA, https://climate.nasa.gov/causes/ [https://perma.cc/MJ63-SEAP] (breaking down the science behind climate change and the role of greenhouse gases (GhGs)).

[86] *See* Cho, *supra* note 4 (discussing the impact crypto mining will have on the global climate goals); *Bitcoin Energy Consumption Index*, DIGICONOMIST, https://digiconomist.net/bitcoin-energy-consumption [https://perma.cc/XV6Q-PASD] (graphing the enormous amount of energy used by Bitcoin).

[87] Cho, *supra* note 4.

[88] *Id.*

bined.[89] Thus, measured in terms of energy consumption, crypto is an extreme outlier even when compared to other computer-intensive companies.

Further, crypto's energy consumption has risen continually, and will likely continue to rise, for two reasons. First, "miners must continually increase their computing power to compete with other miners,"[90] and increasing computing power requires more energy.[91] Second, as PoW cryptos become more popular and more mining companies join a PoW network, the math problem automatically becomes more complex.[92] This forces all miners to use more computing power and, thus, more energy to attempt to solve the math problem.[93]

Crypto's energy consumption is projected to increase significantly.[94] For example, the Texas grid operator estimates that by the end of 2023, crypto miners will increase energy demand in Texas alone by up to six gigawatts.[95] This will be equivalent to adding another Houston—the fourth most populous city in the nation[96]—to Texas's already strained grid.[97]

Electricity is created by fuel. The three major categories of energy for electricity generation are: (1) fossil fuels, including coal, natural gas, and petroleum; (2) nuclear energy; and (3) renewable energy sources, including wind, hydropower, and solar.[98]

Several studies have been conducted to determine what percentage of crypto's energy usage is powered by fossil fuels.[99] From September 2019 to

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[89] *Id.*

[90] *Id.*

[91] *See* Thomson, *supra* note 54, at 84 (discussing the relationship between the increase in equation difficulty, required computing capacity, and energy demands).

[92] *Id.*

[93] Andrew R. Chow, *Fact-Checking 8 Claims About Crypto's Climate Impact*, TIME (July 1, 2022), https://time.com/6193004/crypto-climate-impact-facts/ [https://perma.cc/P3XR-B6UC].

[94] Carroll, *supra* note 17, at 57; Hinsdale, *supra* note 66.

[95] Hinsdale, *supra* note 66.

[96] *About Houston: Facts and Figures*, CITY OF HOUS., TEX., https://www.houstontx.gov/about houston/houstonfacts.html [https://perma.cc/3FX5-PKFU].

[97] Hinsdale, *supra* note 66. Furthermore, the rise of PoW mining operations in the United States has added to the strain on power grids in states like Texas, which were already experiencing issues with providing enough electricity to their customers. Justine Calma, *Texas' Fragile Grid Isn't Ready for Crypto Mining's Explosive Growth*, THE VERGE (July 14, 2022), https://www.theverge.com/2022/7/14/23206795/bitcoin-crypto-mining-electricity-texas-grid-energy-bills-emissions [https://perma.cc/YJF7-BNW5]; *see also* Evan Halper, *Amid Explosive Demand, America Is Running Out of Power*, WASH. POST (Mar. 7, 2024), https://www.washingtonpost.com/business/2024/03/07/ai-data-centers-power/ [https://perma.cc/8LDJ-9GBH] (explaining how the surge in crypto mining deprives many states of electricity).

[98] *Electricity Explained: Electricity in the United States*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php [https://perma.cc/7A98-BRZM] (June 30, 2023).

[99] *See, e.g.*, Gabriel J.X. Dance, *The Real-World Costs of the Digital Race for Bitcoin*, N.Y. TIMES, https://www.nytimes.com/2023/04/09/business/bitcoin-mining-electricity-pollution.html [https://perma.

August 2021, an average of thirty percent of the electricity used by Bitcoin came from hydroelectric, solar, wind, and other renewable sources.[100] Hydropower in China provided a majority of renewable electricity for Bitcoin during this period.[101] Following China's ban on crypto-asset mining in September 2021, the renewable energy used for Bitcoin has decreased.[102]

Before the rise of crypto mining in the United States, many fossil-fuel-powered plants were shutting down, or significantly reducing their operations, due to lack of demand and efforts to transition to renewable energy sources.[103] Crypto miners, however, have revived such plants by using them to power their mining operations.[104] This is further evidence that PoW miners are heavily reliant on fossil fuels to power their operations.[105]

The extraction and use of fossil fuels harms both human health and the natural environment. Extracting fossil fuels harms local ecosystems.[106] Using fossil fuels, meanwhile, directly harms human health by exposing humans to carcinogens,[107] acidifying oceans,[108] and contributing to climate change.[109] Because PoW mining depends mainly on fossil fuels,[110] PoW mining contrib-

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cc/F5J8-R3WL] (Jan. 3, 2024) (discussing a report from WattTime and its findings of the energy usage of cryptos).

[100] WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, CLIMATE AND ENERGY IMPLICATIONS OF CRYPTO-ASSETS IN THE UNITED STATES 24 (2022). This report is discussed further in Part II.B. *See infra* notes 160–181.

[101] WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *supra* note 100, at 24.

[102] *Id.*

[103] Cho, *supra* note 4.

[104] *Id.* For example, in 2020, a coal-fired power plant in Montana was slated to close. Oliver Milman, *Bitcoin Miners Revived a Dying Coal Plant—Then CO2 Emissions Soared*, THE GUARDIAN (Feb. 18, 2022), https://www.theguardian.com/technology/2022/feb/18/bitcoin-miners-revive-fossil-fuel-plant-co2-emissions-soared [https://perma.cc/8P7A-S5AW]. A Bitcoin mining company struck a deal with the plant, however, to become the sole recipient of the plant's electricity. Cho, *supra* note 4. The plant was responsible for emitting over 5,000% more tons of carbon dioxide in the second quarter of 2021 than it emitted over the same period in 2020. Milman, *supra*.

[105] *See* Milman, *supra* note 104 (discussing the massive boost in powerplant emissions stemming from crypto mining); Cho, *supra* note 4 (explaining that crypto requires so much energy that it has allowed dying power plants to revitalize).

[106] *Greenhouse Gases: What Are the Trends in Greenhouse Gas Emissions and Concentrations and Their Impacts on Human Health and the Environment?*, *supra* note 5.

[107] *See* Jackie Weidman & Susannah Marshall, *Soot Pollution 101: What You Need to Know and How You Can Prevent It*, CTR. FOR AM. PROGRESS (Aug. 10, 2012), https://www.americanprogress.org/article/soot-pollution-101/ [https://perma.cc/89T9-TVSM] (explaining that inhaling soot from fossil fuel emissions can cause cancer, among other health issues).

[108] Melissa Denchak, *Fossil Fuels: The Dirty Facts*, NAT. RES. DEF. COUNCIL (June 1, 2022), https://www.nrdc.org/stories/fossil-fuels-dirty-facts#sec-whatis [https://perma.cc/7VJR-N9ZP].

[109] *Greenhouse Gases: What Are the Trends in Greenhouse Gas Emissions and Concentrations and Their Impacts on Human Health and the Environment?*, *supra* note 5.

[110] *See generally* WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *supra* note 100, at 21–23 (explaining the energy usage stemming from crypto mining and the emissions it produces).

utes to all these harms.[111] Furthermore, damage caused by crypto mining is expected to increase due to the expected increase in PoW mining's energy usage over the next several decades.[112]

PoW miners' power consumption has dire implications for climate change and achieving the goals of the Paris Climate Accords.[113] Bitcoin's energy consumption alone produces 22 to 22.9 million metric tons of GhG emissions each year, which is equivalent to the GhG emissions produced from the energy consumption of 2.6 to 2.7 billion homes for one year.[114] In fact, one study estimated that emissions from Bitcoin mining alone could increase global temperatures by two degrees Celsius by the end of the century.[115] This is significant because scientists have long agreed that global warming beyond two degrees Celsius would pose serious risks to human life.[116]

II. Regulatory Efforts and Obstacles

In the United States, there is a growing awareness of the environmental harms caused by crypto mining, which has resulted in government efforts to assess and regulate those harms.[117] This awareness continues to increase as the United States is now the largest source of Bitcoin mining activity in the world—approximately 37 to 38% of global Bitcoin mining occurs in the United States.[118] As crypto mining facilities pop up around the nation, the growth and effects of mining are hard to ignore.[119]

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[111] *Id.*

[112] *See, e.g.*, Calma, *supra* note 96 (illustrating the projected boom in energy usage from crypto).

[113] Cho, *supra* note 4; *see* Shane Sullivan, Note, *Protecting America from Itself: Can the Emerging Principle of Non-Regression Help the United States Resolve the Existential Threat of Climate Disaster?*, 64 B.C. L. Rev. 2089, 2090–92 (2023) (explaining the stark adjustments that the world, and the United States specifically, needs to make in order to achieve the goals of the 2016 Paris Climate Accords).

[114] Cho, *supra* note 4.

[115] Camilo Mora et al., *Bitcoin Emissions Alone Could Push Global Warming Above 2°C*, 8 Nature Climate Change 931, 931 (2018).

[116] Lindsay Fendt, *Why Did the IPCC Choose 2°C as the Goal for Limiting Global Warming?*, MIT Climate Portal (June 22, 2021), https://climate.mit.edu/ask-mit/why-did-ipcc-choose-2deg-c-goal-limiting-global-warming [https://perma.cc/2LSW-Z7L4].

[117] *See generally* Robert Donovan & Matthew Blumenfeld, PricewaterhouseCoopers, PwC Global Crypto Regulation Report 2023 (2022) (detailing the growing appetite to regulate the crypto market, both in the United States and abroad).

[118] *See* Hiroko Tabuchi, *Cryptomining Capacity in U.S. Rivals Energy Use of Houston, Findings Show*, N.Y. Times, https://www.nytimes.com/2022/07/15/climate/cryptocurrency-bitcoin-mining-electricity.html [https://perma.cc/JDF9-QMUY] (July 17, 2022) (reporting that 37% of global Bitcoin mining occurs in the United States); Press Release, *supra* note 58 (reporting that 38% of global Bitcoin mining occurs in the United States).

[119] *See* Dance, *supra* note 99 (stating that despite the slight decline of the crypto market, mines keep spreading across the country).

As the nation becomes more aware of the harms caused by crypto mining, political leaders turn their attention to the environmental impact of crypto miners' energy usage.[120] They have investigated solutions and begun proposing ways to regulate crypto mining to mitigate those harms.[121]

Current U.S. environmental regulations—in particular, the CAA—do not apply to crypto miners. The CAA regulates only sources of pollution directly emitting GhGs to the atmosphere, like smokestacks at an energy plant, and not the consumers for whom the energy plant burns fuel.[122] As crypto miners merely consume the energy from energy plants, they indirectly create emissions and thus fall outside the jurisdiction of the CAA.[123] Because of this gap, the United States government currently lacks the authority to directly regulate crypto miners' energy consumption, despite their being the cause of substantial GhG emissions.[124] This regulatory hole, combined with the intense and increasing energy usage by PoW crypto miners, is generating significant interest in Washington, D.C. to create environmental regulations specific to crypto mining.[125]

Crypto is not the only industry to dodge the reach of the CAA by indirect GhG emissions.[126] For example, Microsoft, Google, Apple, and Meta all use significant amounts of energy to maintain their massive server farms keeping their websites and applications secure and running.[127] Congress, the White

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[120] *See infra* notes 139–159 and accompanying text (discussing Congress's growing interest in regulating the crypto industry).

[121] *See infra* notes 139–159 and accompanying text (noting the steps that specific members of Congress have taken to begin regulating crypto).

[122] *See* Story, *supra* note 7, at 44–45 (noting that the CAA does not apply to data centers). Data centers, like crypto mining operations, consume large amounts of energy but do not directly emit GHGs. *See id.* (discussing the CAA, and explaining that the energy consumers, or the parties demanding the energy, do not fall under its jurisdiction).

[123] *See* WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *supra* note 100, at 21–23 (discussing the energy consumption habits of the crypto industry).

[124] *See* Story, *supra* note 7, at 44–45 (discussing the boundaries of the CAA, which does not encompass energy users, only producers).

[125] *See infra* notes 139–159 and accompanying text (discussing the efforts of lawmakers to regulating the budding crypto industry).

[126] *See generally United States Green Data Center Market Outlook & Forecast Report 2023–2028: Hyperscale Players Such as AWS, Google, Meta, Microsoft, and Apple Are Procuring Renewable Energy for Their Facilities—ResearchAndMarkets.com*, BUSINESSWIRE (Apr. 14, 2023), https://www.businesswire.com/news/home/20230414005157/en/United-States-Green-Data-Center-Market-Outlook-Forecast-Report-2023-2028-Hyperscale-Players-Such-as-AWS-Google-Meta-Microsoft-and-Apple-are-Procuring-Renewable-Energy-for-Their-Facilities%E2%80%94-ResearchAndMarkets.com [https://perma.cc/E9XV-2M9X] [hereinafter *United States Green Data Center Forecast Report*] (discussing these companies' energy usage and energy sources for their data centers).

[127] *Id.*; *Electricity Consumption Among Leading Tech Companies Worldwide in 2022, by Company*, STATISTA, https://www.statista.com/statistics/1250731/electricity-consumption-top-tech-companies-worldwide/ [https://perma.cc/A6X6-2H27].

House, and the EPA, however, have focused solely on crypto miners for several reasons. First, crypto miners use far more energy than all of those technology companies combined.[128] Second, miners' energy usage has continuously increased and is estimated to continue to do so.[129] In contrast, most of those technology companies have become more energy-efficient.[130] Third, crypto miners have a less energy-intensive alternative—PoS mining—at their disposal,[131] and the ability of crypto currency to switch to this alternative has a proven track record—the second largest cryptocurrency, Ethereum, made that switch in 2022.[132] Technology companies do not have such a "silver bullet" alternative as an option. Fourth, some political leaders and their constituents believe that crypto mining—unlike social media, artificial intelligence, search, or productivity software—produces something with little or no social value.[133] As such, according to this viewpoint, PoW mining's energy usage is wasteful and contributes needlessly to pollution without improving society.[134]

This Part digs deeper into Congress's perception of the crypto industry and what it is doing to respond to the industry's growth.[135] Section A looks specifically at the legislature.[136] Section B reviews the executive.[137] Finally, Section C discusses the fear that regulation will smother the industry and explains how this fear holds the government back from swifter action.[138]

A. Congressional Interest and Activity

Senator Elizabeth Warren was the first elected official to effectively raise concerns about the environmental harm caused by crypto mining. In 2021, she

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[128] *Compare United States Green Data Center Forecast Report*, *supra* note 126 (identifying the efforts of Big Tech to use more sustainable energy sources for their data centers), *with* Dance, *supra* note 99 (describing the massive amount of energy that Bitcoin mining farms use).

[129] Dance, *supra* note 99.

[130] *United States Green Data Center Forecast Report*, *supra* note 126.

[131] Moritz Platt et al., *The Energy Footprint of Blockchain Consensus Mechanisms Beyond Proof-of-Work*, 2021 INST. OF ELEC. & ELECS. ENG'RS 21ST INT'L CONF. ON SOFTWARE QUALITY, RELIABILITY & SEC. COMPANION 1135, 1135–36 (2021), https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9741872 [https://perma.cc/2BEU-A5LZ].

[132] *Proof-of-Stake (PoS)*, ETHEREUM, https://ethereum.org/en/developers/docs/consensus-mechanisms/pos/ [https://perma.cc/Z2XZ-WEBY] (Jan. 25, 2024).

[133] Bjarke Smith-Meyer, *How the Left Is Tackling Crypto*, POLITICO (May 10, 2022), https://www.politico.eu/article/does-the-left-hate-crypto/ [https://perma.cc/S3UR-C4FF] (discussing liberal politicians' distrust of the cryptocurrency system).

[134] *Id.*

[135] *See infra* notes 139–184 and accompanying text.

[136] *See infra* notes 139–159 and accompanying text.

[137] *See infra* notes 160–181 and accompanying text.

[138] *See infra* notes 182–184 and accompanying text.

voiced her alarm in a congressional hearing[139] and then sent inquiries to large miners operating in the United States about their energy consumption and environmental impact.[140]

Senator Warren's apprehensions sparked several rounds of congressional inquiries into the environmental impacts of crypto mining.[141] Since she brought these environmental concerns to the forefront, the United States government—from Congress to the White House and the EPA—has focused on the best way to reign in crypto's environmental harm.[142]

Senator Warren's initial concerns were followed by further efforts by other members of Congress to gather more information about crypto's deleterious environmental impact. Congressional leaders have held hearings,[143] made inquiries, and corresponded with crypto miners and the EPA about the industry's energy use and the resulting environmental harms.[144]

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[139] *Building a Stronger Financial System: Opportunities of a Central Bank Digital Currency: Hearing Before the Subcomm. on Econ. Pol'y of the S. Comm. on Banking, Hous., & Urb. Affs.*, *supra* note 3, at 1–3.

[140] Letter from Sen. Elizabeth Warren to Jeffrey Kirt, CEO, Greenridge Generation Holdings, Inc. (Dec. 2, 2021), https://www.warren.senate.gov/imo/media/doc/2021.12.2.%20Letter%20to%20Greenidge%20Generation%20on%20Crypto.pdf [https://perma.cc/6HZR-39DM].

[141] *See* Jeffrey M. Kelly & Jeffrey E. Joseph, *Cleaning Up Cryptocurrency: U.S. Congress Investigates the Environmental Impact of Crypto Mining Setting the Stage for a New Frontier for Renewables—Green Crypto Mining*, NELSON MULLINS (Feb. 4, 2022), https://www.nelsonmullins.com/insights/alerts/megawatt-minute/all/cleaning-up-cryptocurrency-u-s-congress-investigates-the-environmental-impact-of-crypto-mining-setting-the-stage-for-a-new-frontier-for-renewables-green-crypto-mining [https://perma.cc/6QQJ-KC5Q] (detailing the 2021 Senate hearing and subsequent inquiries); Aoyon Ashraf & Eliza Gkritsi, *Witnesses Debate Crypto Mining's Efficiency in Congressional Hearing on Environment*, COINDESK, https://www.coindesk.com/policy/2022/01/21/witnesses-debate-crypto-minings-efficiency-in-congressional-hearing-on-environment/ [https://perma.cc/2AY9-HJ9F] (May 11, 2023) (describing the House hearing held shortly after the Senate hearing in January 2022).

[142] *See, e.g.*, Gkritsi & De, *supra* note 3 (discussing the White House's efforts to address the environmental impact of crypto mining); Ashley Belanger, *Cryptomining Boom Has People's Energy Bills Skyrocketing; Feds Mull New Rules [Updated]*, ARS TECHNICA (July 18, 2022), https://arstechnica.com/tech-policy/2022/07/cryptomining-boom-has-peoples-energy-bills-skyrocketing-feds-mull-new-rules/ [https://perma.cc/3ZSN-Q2CL] (discussing congressional efforts to address the environmental impact of crypto mining); Nicolas Vega, *Members of Congress Are Asking the EPA to Investigate the Environmental Impacts of Crypto Mining*, CNBC (Apr. 22, 2022), https://www.cnbc.com/2022/04/22/democrats-want-epa-to-investigate-impacts-of-crypto-mining.html [https://perma.cc/4ATN-EPGE] (discussing lawmakers' demand for EPA action regarding crypto energy usage).

[143] *See generally Cleaning Up Cryptocurrency: The Energy Impacts of Blockchains*, ENERGY & COM. (Jan. 20, 2022), https://energycommerce.house.gov/events/cleaning-up-cryptocurrency-the-energy-impacts-of-blockchains [https://perma.cc/9KAY-H5ND] (illustrating that on January 20, 2022, the U.S. House of Representatives' Committee on Energy and Commerce's Subcommittee on Oversight and Investigations held a hearing that focused on the amount of energy used to power PoW mining and the resulting environmental harms).

[144] *See* Press Release, Sen. Elizabeth Warren, Warren, Colleagues Press Six Cryptomining Companies on Extraordinarily High Energy Use and Climate Impacts (Jan. 27, 2022), https://www.warren.senate.gov/newsroom/press-releases/warren-colleagues-press-six-cryptomining-companies-on-extraordinarily-high-energy-use-and-climate-impacts [https://perma.cc/AT3P-RQ6D] (including the

Subsequently, several members of Congress have taken the additional step of drafting bills addressing crypto miners' energy usage and environmental impact, though none so far have proposed an actual, detailed regulatory plan.[145] So far, the primary focus in attempting to regulate crypto has been financial—preventing fraud and regulating crypto as an investment.[146] Thus, even the bills addressing environmental harm merely direct government agencies to begin collecting data about crypto mining's energy usage and environ-

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text of the letters to the companies); Letter from Sen. Elizabeth Warren to Michael Regan, Adm'r, EPA, & Jennifer Granholm, Sec'y, Dep't of Energy (Feb. 6, 2023), https://www.warren.senate.gov/imo/media/doc/2023.02.06%20Follow-Up%20Letter%20to%20EPA%20and%20DOE%20Re%20Cryptomining%20Environmental%20Impacts2.pdf [https://perma.cc/GCX6-X5CQ] (illustrating the exchange between Senator Warren, the EPA, and the Department of Energy). On January 27, 2022, eight members of Congress sent letters to six crypto mining companies raising concerns over the miners' energy consumption and impacts on the environment and climate. Press Release, *supra*. The companies responded, admitting to using significant amounts of energy. *See, e.g.*, Letter from Jason Les, CEO, Riot Blockchain, Inc., to Sen. Elizabeth Warren, Sen. Sheldon Whitehouse, Sen. Jeffrey A. Merkley, Sen. Margaret Wood Hassan, Sen. Edward J. Markey, Rep. Katie Porter, Rep. Rashida Talib & Rep. Jared Huffman (Feb. 24, 2022), https://www.warren.senate.gov/imo/media/doc/Riot%20Response%20Letter%202.24.20223.pdf [https://perma.cc/3DZS-ZGRT] (illustrating Riot Blockchain's response to the congressional letters regarding energy usage); Letter from Bryan Bullett, CEO, Bit Digital, Inc., to Sen. Elizabeth Warren, Sen. Sheldon Whitehouse, Sen. Jeffrey A. Merkley, Sen. Margaret Wood Hassan, Sen. Edward J. Markey, Rep. Rashida Talib, Rep. Jared Huffman & Rep. Katie Porter (Feb. 18, 2022), https://www.warren.senate.gov/imo/media/doc/Bit%20Digital%20Response%20Letter%202.18.20221.pdf [https://perma.cc/3WVD-MDMT] (depicting Bit Digital's question-by-question responses to the congressional inquiry). Then, on April 20, 2022, on behalf of twenty-three members of Congress, Representative Jared Huffman sent a letter to the EPA stating that those representatives had "serious concerns regarding reports that cryptocurrency facilities across the country are polluting communities and are having an outsized contribution to [GhG] emissions." Letter from Rep. Jared Huffman to Michael Regan, Adm'r, EPA (Apr. 20, 2022), https://www.ewg.org/sites/default/files/2022-04/Crypto%20letter%20to%20EPA.pdf [https://perma.cc/U55D-LWP3]. Additionally, the letter stated that crypto miners must be held accountable for their environmental harm and "[the United States government] must ensure communities are not left with the toxic burdens associated with this technology." *Id.* Congressman Huffman also individually pledged to push the Biden Administration to "address these significant environmental and climate impacts." Stephen Lee, *EPA Acknowledges Plans to Look at Crypto Energy Usage, Emissions*, BLOOMBERG L. (Nov. 21, 2022), https://news.bloomberglaw.com/environment-and-energy/epa-acknowledges-plans-to-look-at-crypto-energy-usage-emissions [https://perma.cc/UBF8-D2HS].

[145] *See, e.g.*, Lummis-Gillibrand Responsible Financial Innovation Act, S. 4356, 117th Cong. § 403 (2022) (exemplifying the Responsible Financial Innovation Act's proposal to split regulatory authority between the SEC and the CFTC). The bill also would require yearly reports from the Federal Energy Regulatory Commission on crypto's energy consumption. *Id.* § 806(a). Further, the Digital Commodities Consumer Protection Act proposes providing the CFTC jurisdiction over cryptos. *See generally* S. 4760, 117th Cong. (2022). It also would require the CFTC to publish and update a report on the energy consumption and sources of energy used by crypto miners. *Id.* § 5i(g).

[146] *See supra* note 145 and accompanying text (showing bill proposals that focus on regulating the industry as a financial device rather than an environmental threat).

mental impact.[147] None of these efforts, however, propose actual environmental regulations for crypto;[148] this Article does.

Furthermore, due at least in part to the Supreme Court's 2022 holding in *West Virginia v. EPA*, it would be difficult, if not impossible, for the EPA to regulate crypto miners through its current authority.[149] Because miners are merely energy consumers, and the CAA covers only direct emissions, the current statutory regime lacks the express language granting the EPA power to regulate crypto miners required by *West Virginia*.[150] Therefore, new legislation is necessary to specifically address crypto mining's environmental harms, either as part of a broader package regulating crypto or one solely addressing crypto mining's environmental harms.

In bills enacting environmental regulations, Congress typically assigns authority to an agency and gives the agency general directions regarding implementation.[151] Congress generally leaves many of the details for the agency to decide and implement, however.[152] For example, in Section 109 of the 1990 amendments to the CAA, legislators require the EPA to set National Ambient Air Quality Standards (NAAQS) for air pollutants that endanger public health.[153] Section 109 explains that the NAAQS "must be designed to protect public health with an adequate margin of safety."[154] But it does not set out precisely what those standards should be—that was left for the EPA to determine.[155]

The flurry of activity on Capitol Hill indicates that Congress seems at least interested in considering environmental legislation for crypto miners.[156] But many members of Congress, including those who have expressed an inter-

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[147] *See supra* note 145 and accompanying text (discussing the fledgling attempts to regulate the crypto industry).

[148] *See supra* note 145 and accompanying text (illustrating that Congress has not yet gone far enough in its regulation attempts).

[149] *See* 597 U.S. 697, 721, 724–25 (2022) (ruling that Congress needs to clearly delegate the authority to the EPA or another government agency to promulgate environmental regulations for a "major question" of extraordinary economic and political significance).

[150] *See id.* (requiring explicit language within a statute if an administrative agency wishes to justify expanding its power); 42 U.S.C. § 7602(j), (z) (defining stationary sources as direct emitters of pollution, not secondary emitters).

[151] *See* TODD GARVEY & DANIEL J. SHEFFNER, CONG. RSCH. SERV., R45442, CONGRESS'S AUTHORITY TO INFLUENCE AND CONTROL EXECUTIVE BRANCH AGENCIES 8–11 (2018) (describing the process through which Congress can direct an agency towards a particular goal through legislation).

[152] *Id.*

[153] Clean Air Act Amendments of 1990, Pub. L. No. 101-549, 104 Stat. 2399 (codified as amended at 42 U.S.C. §§ 7401–7671); *see also* RICHARD K. LATTANZIO, CONG. RSCH. SERV., RL 30853, CLEAN AIR ACT: A SUMMARY OF THE ACT AND ITS MAJOR REQUIREMENTS 3 (2022).

[154] LATTANZIO, *supra* note 153, at 3; *see* 42 U.S.C. § 7409.

[155] *See* LATTANZIO, *supra* note 153, at 3; 42 U.S.C. § 7409.

[156] *See supra* notes 139–148 and accompanying text (summarizing the efforts of Senator Warren and other lawmakers, including the White House, to begin regulating crypto).

est in promulgating environmental regulations for the industry, have also expressed concerns that such regulation will stifle innovation and competition.[157]

This Article's proposal suggests a win-win solution through an innovation- and competition-stimulating regulatory scheme that would also lessen miners' environmental harms.[158] This regulatory program could be implemented by Congress enacting enabling legislation and the agency promulgating regulations—likely the EPA—pursuant to that delegated authority.[159] This approach should help get more congressional votes for environmental legislation about crypto mining.

B. President Biden's Executive Order and DAME Tax

President Biden also expressed concern about the environmental harm of crypto mining and advanced regulatory fixes while similarly indicating that such regulation should not unduly stifle competition and innovation in the industry.[160] In March 2022, President Biden issued an executive order calling on several government agencies to study crypto mining's impact on the environment, how to make crypto greener, and to consider the best ways to regulate crypto mining's environmental harms.[161] President Biden explained that his priorities for this executive order, and any future environmental regulations, were to encourage innovation in crypto mining while also protecting the nation from its negative effects.[162] He directed the Director of the White House's Office of Science and Technology Policy (OSTP), in consultation with the heads of several other agencies, to submit a report analyzing crypto mining's connec-

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[157] *See, e.g.*, Press Release, Sen. Kirsten Gillibrand, Lummis, Gillibrand Introduce Landmark Legislation to Create Regulatory Framework for Digital Assets (June 7, 2022), https://www.gillibrand.senate.gov/news/press/release/lummis-gillibrand-introduce-landmark-legislation-to-create-regulatory-framework-for-digital-assets/ [https://perma.cc/D4JH-CRQ8] (discussing the importance of Congress implementing regulations that promote innovation in the crypto industry); Press Release, Rep. Ro Khanna, Khanna, Thompson, Emmer, Soto Introduce Bipartisan Digital Commodity Exchange Act of 2022 (Apr. 28, 2022), https://khanna.house.gov/media/press-releases/khanna-thompson-emmer-soto-introduce-bipartisan-digital-commodity-exchange-act [https://perma.cc/54MU-L5CC] (same); Molly Ball, *Crypto Goes to Washington*, TIME (Oct. 3, 2022), https://time.com/6215042/crypto-washington-dc-regulation/ [https://perma.cc/LJE5-L5YD] (reporting that "policymakers say they want to protect consumers and foster innovation").

[158] *See infra* Part IV.

[159] *See infra* Part IV (discussing how the proposal could be implemented through enabling legislation and ensuing EPA regulations).

[160] Ensuring Responsible Development of Digital Assets, Exec. Order No. 14067, 87 Fed. Reg. 14143, 14145, 14148 (Mar. 9, 2022).

[161] *Id.*

[162] *See* Press Release, *supra* note 9 (announcing that the goal of the executive order is to mitigate the risks of crypto mining, but still allow the industry to continue its growth).

tion to energy usage, environmental harm, and climate change, as well as potential mitigating measures and alternative mechanisms of mining.[163]

In September 2022, the OSTP published the report.[164] The report concluded that crypto mining, particularly PoW mining, uses significant amounts of energy, especially fossil fuels, and undermines national environmental goals.[165] It also determined that miners could use renewables to power their operations and decrease their impact on the environment, but are not currently doing so in significant numbers.[166] Additionally, the report identified PoS as a less-energy-intensive alternative to PoW.[167]

The report called for several federal agencies to conduct further research on the environmental impact of crypto mining as a foundation of future environmental regulations for crypto mining.[168] It also suggested that Congress pass legislation forcing consensus mechanisms to consume less energy or eliminate PoW systems altogether.[169]

Shortly after the report was issued, as part of the Administration's proposed 2024 budget, President Biden proposed the Digital Asset Mining Energy excise tax (DAME Tax).[170] Under this tax, crypto miners would pay a tax of thirty percent of the cost of all electricity used to mine crypto, regardless of the source of that fuel.[171] According to the administration, the DAME Tax would encourage crypto miners to more conscientiously track their impact on the environment.[172] The Administration did not mention how this tax would impact innovation or competition.[173] Notably, however, it appears unlikely that Congress will adopt the DAME Tax.[174]

Though the OSTP report suggested that Congress consider banning PoW mining,[175] this Article does not propose such a blunt solution. An outright ban

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[163] Ensuring Responsible Development of Digital Assets, Exec. Order No. 14067, 87 Fed. Reg. at 14148.

[164] *See generally* WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *supra* note 100 (illustrating the findings of the White House).

[165] *Id.* at 6.

[166] *Id.* at 23–25.

[167] *Id.* at 6, 10–11, 32.

[168] *Id.* at 8.

[169] *Id.* at 7.

[170] *The DAME Tax: Making Cryptominers Pay for Costs They Impose on Others*, *supra* note 13.

[171] *Id.*

[172] *Id.*

[173] *See id.* (omitting any mention of the DAME Tax's influence on the growth of the cryptocurrency industry).

[174] *See* Jeff Stein & Tony Romm, *Biden Calls for Trillions in Tax Hikes and New Domestic Spending*, WASH. POST, https://www.washingtonpost.com/us-policy/2023/03/09/biden-budget-economy-policy-republicans/ [https://perma.cc/SC6M-NSFN] (Mar. 9, 2023) (reporting that "[t]he budget is highly unlikely to pass through a Republican-controlled House").

[175] WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *supra* note 100, at 7.

would likely result in PoW miners moving their operations to another country, thus failing to solve the environmental problems caused by crypto mining and harming many local economies.

This Article does suggest imposing a pollution tax, but one that is more nuanced and innovation-friendly than the DAME Tax. Unlike the DAME Tax, the proposed regulatory program does not levy a tax on renewable energy consumption. It taxes miners only for using fossil fuels, a critical distinction given that the use of fossil fuels has a more severe environmental impact than the use of renewable energies. The difference in approaches flows from following the PH principles, which the DAME Tax does not do. A more in-depth comparison of the Article's proposal to both the DAME Tax and a ban of PoW can be found in Part IV.[176]

In short, there is significant interest from Congress and the executive branch for environmental regulations for crypto mining.[177] Both branches, however, do not want such regulation to stimy innovation and competition.[178] Furthermore, the prospects for actual passage of a regulatory program seem dim unless the program can accommodate those goals.[179] Likewise, Congress has yet to propose specific environmental regulations for crypto mining, and the specific proposals advanced by the executive have significant shortcomings.[180] This Article's proposal, found in Part IV, achieves both branches' goals by encouraging innovation and competition while also reducing miners' environmental impact—a political success that would likely help garner more congressional support to enact environmental legislation for crypto mining.[181]

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[176] *See infra* notes 287–516 and accompanying text.

[177] *See supra* notes 139–175 and accompanying text.

[178] *See supra* note 157 and accompanying text (discussing congressional efforts to open up new regulations in the crypto industry); *see also* Ensuring Responsible Development of Digital Assets, Exec. Order No. 14067, 87 Fed. Reg. 14143, 14143–45 (Mar. 9, 2022) (discussing the importance of future crypto regulations allowing the crypto industry to continue to innovate); WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *supra* note 100, at 6, 10–11, 32 (same).

[179] *Cf., e.g.*, David Shepardson, *Republican Senators Seek to Reverse U.S. Heavy-Duty Truck Emissions Rule*, REUTERS (Feb. 9, 2023), https://www.reuters.com/world/us/republican-senators-seek-reverse-us-heavy-duty-truck-emissions-rule-2023-02-09/ [https://perma.cc/94YR-CJ7N] (explaining that a coalition of Republican members of Congress issued a joint statement opposing new EPA regulations on heavy-duty truck emissions); Benjamin J. Hulac, *Sweeping GOP Energy Bill Would Sweep Away Biden's Climate Agenda*, ROLL CALL, https://rollcall.com/2023/03/14/sweeping-gop-energy-bill-would-sweep-away-bidens-climate-agenda/ [https://perma.cc/M7WV-25LZ] (Mar. 14, 2023) (stating that a new Republican bill in the House takes aim at many major tenets of President Biden's climate agenda).

[180] *See The DAME Tax: Making Cryptominers Pay for Costs They Impose on Others*, *supra* note 13 (proposing an energy tax that fails to adhere to all the goals of the PH).

[181] *See infra* notes 287–516 and accompanying text.

C. Obstacles to Regulation: Concerns About Stunting Innovation and Competition

While Capitol Hill and the White House have been pursuing regulation of crypto miners, the industry itself has significantly increased its lobbying efforts in attempt to head off regulation.[182] Generally, the industry wants to preserve its abilities to innovate and compete, and it fears that regulation would hamper both.[183] As just discussed, members of Congress and the executive branch share this concern, which has reduced momentum for environmental regulation of crypto mining.[184]

This Article proposes, based on the PH's principles, a win-win approach that would promote innovation and stimulate competition, while also reducing miners' environmental harms. It further proposes a regulatory process that is grounded in consultation with, and takes a non-adversarial approach to, industry. This approach could help to get the industry "on board" with regulation and increase congressional support for environmental legislation for crypto mining.

III. SOLVING THE REGULATORY DILEMMA BY APPLYING THE PORTER HYPOTHESIS TO CRYPTO REGULATION

In devising a program of environmental regulations for crypto, the PH provides a theory and set of principles that can drive a regulatory program to spur innovation and competition along the way toward reducing environmental

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[182] Newmyer, *supra* note 15. In 2020, before Congress had mining under its microscope, the crypto industry spent $2 million on lobbying. *Id.* Then, in 2021, as discussions about regulating crypto increased, crypto spent $7.7 million on lobbying. *Id.* The industry proceeded to spend $8.9 million during the first half of 2022 alone. *Id.* Several large crypto companies have also launched their own political action committees to influence politicians. Caitlin Oprysko, *Binance Forms a PAC*, POLITICO (Nov. 22, 2022), https://www.politico.com/newsletters/politico-influence/2022/11/22/binance-forms-a-pac-00070569 [https://perma.cc/5FM3-MCRL].

[183] *See Why Regulation Won't Harm Cryptocurrencies*, KNOWLEDGE AT WHARTON (Apr. 27, 2021), https://knowledge.wharton.upenn.edu/podcast/knowledge-at-wharton-podcast/why-regulation-wont-harm-cryptocurrencies/ [https://perma.cc/N5N3-9KJ9] (discussing the worries related to increased regulation of crypto); Caitlin Clark, *What the Biden Administration's Executive Order Means for the Crypto Industry*, TEX. A&M TODAY (Mar. 31, 2022), https://today.tamu.edu/2022/03/31/what-the-biden-administrations-executive-order-means-for-the-crypto-industry/ [https://perma.cc/GMA4-9B6F] (explaining that many crypto insiders "worry that regulation will hurt the industry and related innovation").

[184] *See supra* note 144 and accompanying text (describing Senator Warren's efforts to raise the alarm about the risks present in the crypto industry); Jesse Hamilton & Jack Schickler, *U.S. Stablecoin Bill Takes Big Step Despite Fight from Democrats, White House*, COINDESK, https://www.coindesk.com/policy/2023/07/28/us-stablecoin-bill-takes-big-step-despite-fight-from-democrats-white-house/ [https://perma.cc/9U8T-5GG6] (July 28, 2023) (explaining how Democrats are resisting Republican attempts to pass crypto legislation).

harm.[185] This push, in turn, would likely garner more political support and reduce industry opposition. This Part first explains the PH, and then the resulting benefits if a regulatory program were implemented for crypto mining based on the PH's principles.[186] Section A breaks down the origins and substance of the PH.[187] Then, Section B illustrates successful examples of the PH operating in the real world.[188] Finally, Section C briefly explains why the PH would be so beneficial in tackling the crypto emissions problem.[189] Having explained the PH's principles, the Article applies them in Part IV to the regulation of crypto mining and uses them to propose a regulatory program.[190]

A. The Porter Hypothesis: Designing Environmental Regulations That Reduce Environmental Harm and Promote Innovation and Competition

The PH theorizes that environmental regulations can encourage innovation and competition within the regulated industry and explains what regulatory principles most often lead to these benefits.[191] These principles of the PH include recommendations about the regulatory process, the substance of the regulations themselves, and successful implementation.[192]

The PH posits that "properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with [the standards]."[193] The hypothesis was first put forward in a paper by

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[185] *See* Porter & van der Linde, *supra* note 22, at 124 (listing the PH's key regulatory principles). Congress's use of new legislation, as opposed to existing legislation like the CAA, makes more sense from a policing standpoint, given the unique characteristics of crypto mining. Enacting new legislation also would avoid any potential obstacles presented by the Supreme Court's ruling in *West Virginia v. EPA* regarding the use of an existing statute to regulate crypto miners. *See* 597 U.S. 697, 724–25 (2022) (ruling that Congress needs to clearly delegate the authority to the EPA or another government agency to promulgate environmental regulations for a "major question" of extraordinary economic and political significance); *see also* Maxine Joselow, *Supreme Court's EPA Ruling Upends Biden's Environmental Agenda*, WASH. POST, https://www.washingtonpost.com/climate-environment/2022/06/30/epa-supreme-court-west-virginia/ [https://perma.cc/ZYC4-KBHM] (June 30, 2022) (discussing the general confusion surrounding environmental agencies' ability to regulate using existing environmental legislation after *West Virginia*).

[186] *See infra* notes 191–286 and accompanying text.

[187] *See infra* notes 191–264 and accompanying text.

[188] *See infra* notes 265–283 and accompanying text.

[189] *See infra* notes 284–286 and accompanying text.

[190] *See infra* notes 287–516 and accompanying text.

[191] *See generally* AMBEC ET AL., *supra* note 20 (summarizing the main arguments of the PH and whether they still apply twenty years after their creation).

[192] *Id.* at 10.

[193] Porter & van der Linde, *supra* note 21, at 98.

Michael Porter and Claas van der Linde published in the 1990s.[194] Essentially, the PH states that regulation can induce technological innovation when industries have, or are forced to develop, the willingness and ability to innovate.[195] That innovation can become a net positive for a company when the added revenue or cost saved is greater than the compliance cost.[196]

The regulatory principles the PH posits—encouraging innovation and competition while also achieving the primary goal of reducing environmental harm—were enumerated by Porter and van der Linde after years of studying global regulations,[197] with a particular focus on and criticism of U.S. environmental regulations.[198]

As for the regulatory process, the PH suggests that prior to drafting any regulations, policymakers improve their understanding of the industry they plan to regulate.[199] Specifically, regulators should understand the economics of the industry and "what drives its competitiveness" so that the regulations are designed to spur, rather than harm, innovation and competition.[200] This will also decrease the likelihood that "companies use an array of lawyers and consultants to try to stall the poorly designed regulations of ill-informed regulators."[201]

Next, legislators and regulators should consult with industry leaders in dialogue throughout the legislative and regulatory processes.[202] More specifically, policymakers should seek industry participation throughout each process, from creating emissions limits to setting the dates for deadlines.[203] This engagement will make achieving other PH principles easier, as it increases the

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[194] *See id.* at 97 (embodying the original proposal by Porter and van der Linde); John M. Amandolare, Note, *Clean Air the Natural Way: A Case for Harmonizing Global Auto Emissions Standards*, 38 SYRACUSE J. INT'L L. & COM. 201, 222 (2010) (explaining the origins of the PH).

[195] Porter & van der Linde, *supra* note 21, at 98; *see also* Nicholas A. Ashford & Ralph P. Hall, *The Importance of Regulation-Induced Innovation for Sustainable Development*, 3 SUSTAINABILITY 270, 277 (2011) (discussing the PH's view of environmental regulation and potential positive impacts on the economy).

[196] *See* Porter & van der Linde, *supra* note 21, at 98 (introducing the idea of "innovation offsets").

[197] Porter and van der Linde enumerated these principles in several different publications. *See generally* Porter & van der Linde, *supra* note 21 (introducing the idea of the PH); Porter & van der Linde, *supra* note 22 (summarizing the PH in a separate publication); Michael E. Porter, *America's Green Strategy*, SCI. AM., Apr. 1991, at 168, 168 (summarizing the PH in another publication years before the original publication).

[198] *See, e.g.*, Porter, *supra* note 197, at 168 ("Because U.S. environmental regulations have traditionally violated [the PH's] principles, the substantial amount we spend on protecting the environment has not yielded the benefits it could have."); Porter & van der Linde, *supra* note 21, at 110 ("[I]t is clear that U.S. environmental regulations have often been crafted in a way that deters innovative solutions, or even renders them impossible.").

[199] Porter & van der Linde, *supra* note 22, at 124.

[200] *Id.*

[201] *Id.*

[202] Porter & van der Linde, *supra* note 21, at 113; Porter & van der Linde, *supra* note 22, at 124.

[203] Porter & van der Linde, *supra* note 21, at 113; Porter & van der Linde, *supra* note 22, at 124.

likelihood that regulators set standards, deadlines, and other requirements that encourage further development of the industry.[204]

The PH also outlines as a principle that legislators and regulators should take a cooperative rather than adversarial stance toward industry during the regulatory process.[205] The PH explains that an adversarial stance is typically not necessary in the modern business landscape.[206] In fact, goals of industry and regulators often align, as innovation and resource efficiency are critical to competitiveness and success.[207] In turn, innovation and resource efficiency typically lead to reduced environmental damage.[208] As part of this cooperative approach, the PH recommends that regulators communicate with and educate industry about their shared interests.[209]

The second group of principles address the substance of the regulations themselves—the substantive principles.[210] The PH indicates that regulations should set emission standards to reduce environmental harm, but give the regulated industry flexibility to meet those standards.[211]Accordingly, when U.S. regulators provide companies with flexibility, they are promoting innovation.[212] The best way to provide such flexibility is through the use of market-based regulatory instruments.[213] Pollution taxes and cap-and-trade programs are two market-based instruments that encourage polluters to reduce or eliminate their pollution by penalizing them financially for improper amounts of pollution.[214] Yet, both regulatory instruments also provide polluters flexibility in deciding how to reduce their pollution.[215]

Furthermore, regulations should not mandate the technology that companies use to meet the regulatory standards.[216] Instead, the regulations should give companies technological freedom to meet those standards.[217] Essentially, this principle means that regulations should allow the industry to decide how to innovate, not the government agency.[218]

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[204] Porter & van der Linde, *supra* note 21, at 113; Porter & van der Linde, *supra* note 22, at 124.
[205] Porter & van der Linde, *supra* note 22, at 128.
[206] *Id.* at 128–29.
[207] *Id.* at 125–26.
[208] *Id.*
[209] *Id.*
[210] AMBEC ET AL., *supra* note 20, at 10.
[211] Porter & van der Linde, *supra* note 21, at 110–11.
[212] *Id.*
[213] Porter & van der Linde, *supra* note 22, at 124.
[214] *Id.*
[215] *See id.* (advocating for the usage of market incentive devices, such "pollution charges" and "tradable permits").
[216] Porter & van der Linde, *supra* note 21, at 110.
[217] *Id.*
[218] *Id.*

The PH also directs a focus on "encourag[ing] product and process changes."[219] There are several ways of accomplishing this. First, policymakers can encourage product and process changes by promulgating regulations that do not allow the use of secondary treatment.[220] Secondary treatment is when polluters merely abate or clean up their pollution just before it has been emitted; many U.S. environmental regulations have allowed this.[221] In contrast, the PH's approach to regulatory implementation prioritizes reducing pollution at the source.[222] In addition, the PH's suggestion to implement phase-in periods and realistic compliance deadlines (as discussed further below) would provide industry with enough time to research and develop (R&D) innovative solutions that reduce pollution by making product or process changes.[223] Policymakers can also encourage product and process changes by using a market incentive, as explained above; miners will be forced to operate differently to avoid emissions or pay a pollution tax.

The final substantive PH principle is that environmental regulations must mandate funding of pilot projects to help encourage innovation that can reduce pollution while also improving competition.[224] The government can fund pilot projects that demonstrate technological innovations, which the industry can then emulate.[225] This process encourages innovation as it provides the industry with R&D ideas and shows the industry what it can achieve.[226] Indeed, the United States has a long history of successfully implementing this tactic.[227]

The last category of PH principles discuss regulation implementation. As mentioned, the PH maintains that regulations should include phase-in periods,[228] which are periods in which lower standards are enforced, before phasing in stricter standards until the final standards are implemented. Such periods provide the industry time to R&D new technologies to help meet the final standards. Likewise, regulations must set compliance deadlines that are realistically achievable.[229] Deadlines that are too short will not provide industry with

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[219] *Id.* at 111.

[220] *Id*.

[221] *End of Pipe Control*, NESTEC (Dec. 5, 2018), https://www.nestecinc.com/news/end-of-pipe-control/ [https://perma.cc/MM7B-37UJ] (explaining the basics of "end-of-pipe" solutions).

[222] Porter & van der Linde, *supra* note 21, at 111.

[223] *Id*.

[224] *Id.* at 110, 112.

[225] *Id.* at 112.

[226] *Id.*

[227] *See id.* (describing the EPA's use of this tactic to help develop new "super-efficient" refrigerator technology).

[228] Porter & van der Linde, *supra* note 22, at 124.

[229] *See id.* at 129 (explaining that the United States improperly sets deadlines that are too short to realistically be achieved).

enough time to R&D innovate productive solutions.[230] Instead of making such changes, industry will likely have to use shortcuts such as secondary treatment of pollution—which is both bad for the environment and not aligned with the PH's principles.[231]

The PH also calls for collection and dissemination of emission information to drive implementation of the regulations and assess their effectiveness. Regulators should gather, disseminate, and publicize pollution information collected from individual miners.[232] Doing so provides companies with knowledge about their impact on the environment that may have previously been unknown to them.[233] This also allows the public, including consumers, to know companies' impact on the environment,[234] which can lead to public pressure to reduce environmental harm.[235] It also would allow companies to compete for customers based on reducing their environmental impact. Tracking this information should also help show if the environmental regulations are working to reduce miners' GhG emissions.

Finally, in terms of implementation, the PH directs that legislators should "[m]ake the regulatory process more stable and predictable."[236] Specifically, legislators can reduce uncertainty by publicly committing to keeping the standards in place for a certain amount of time.[237] Regulatory uncertainty often wards off R&D due to concerns that the regulations will change, subsequently rendering any innovation pointless and wasting the resources used to create it.[238] Conversely, regulatory certainty incentivizes innovation.[239]

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[230] *Id.* at 124.

[231] *Id.*

[232] Porter & van der Linde, *supra* note 21, at 100.

[233] *Id.* at 112.

[234] *Id.*

[235] *Id.* at 100.

[236] Porter & van der Linde, *supra* note 22, at 124.

[237] *Id.*

[238] *Id.*; *see* ORG. FOR ECON. CO-OPERATION & DEV., POLICY FRAMEWORK FOR INVESTMENT: A REVIEW OF GOOD PRACTICES 12–14 (2006) (explaining the need for regulatory certainty if an economy is to grow steadily and successfully); *see also Bangladesh Development Update: Regulatory Predictability Can Sustain High Growth*, WORLD BANK (Apr. 4, 2019), https://www.worldbank.org/en/news/feature/2019/04/04/bangladesh-development-update-regulatory-predictability-can-sustain-high-growth [https://perma.cc/9XWK-ZSRZ] (discussing that the main factor preventing Bangladesh from being a top-tier economy is its lack of predictability in its regulations); Richard M. Rossow, *The Next Economic Hurdle: Regulatory Transparency and Predictability*, CTR. FOR STRATEGIC & INT'L STUD. (Sept. 28, 2016), https://www.csis.org/analysis/next-economic-hurdle-regulatory-transparency-and-predictability [https://perma.cc/7WDS-S5QT] (arguing that if India wishes to reach its full economic potential, it must create a regulatory environment with a foundation of certainty).

[239] *See* Porter & van der Linde, *supra* note 21, at 113 (explaining that when there is regulatory certainty, "industry is motivated to innovate").

According to the PH, if environmental regulation is modelled on these principles, it will have important beneficial effects on innovation and competition. First, regulation modelled on these principles creates "pressure that motivates companies to innovate."[240] Second, it acts as a signal to companies that they may be utilizing resources inefficiently and could make technological improvements that increase resource efficiency.[241] Third, it alleviates uncertainty regarding the value of an investment directed toward addressing environmental issues.[242] Fourth, PH-modelled regulation "level[s] the playing field during the transition period to innovation-based environmental solutions, ensuring that one company cannot gain position by avoiding environmental investments. Regulation provides a buffer for innovative companies until new technologies are proven and the effects of learning can reduce technological costs."[243]

Innovation caused by environmental regulation, according to the PH, involves "address[ing] the root causes of pollution by improving resource productivity in the first place."[244] "Resource productivity improves when less costly materials are substituted or when existing ones are better utilized."[245] This category has great potential to produce lasting change by reducing pollution at the source.[246] The PH also explains that environmental regulations can spur innovation by companies not currently in the industry.[247]

Next, the PH contends that regulation can improve the competitiveness of the regulated industry in two ways: increasing resource efficiency and increasing quality.[248]

Increasing the resource efficiency of production involves decreasing the utilization of harmful resources.[249] Decreasing the use of harmful resources is beneficial because under the new regulation, decreasing the use of such resources also decreases costs[250] and makes the company more competitive in the marketplace.[251] In return, this spurs competition as companies minimize

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[240] Porter & van der Linde, *supra* note 22, at 128.

[241] *Id.*

[242] AMBEC ET AL., *supra* note 20, at 3–4.

[243] Porter & van der Linde, *supra* note 22, at 128.

[244] *Id.* at 125.

[245] *Id.*

[246] *See id.* (considering solutions that tackle pollution at the source as "far more interesting and important").

[247] Ashford & Hall, *supra* note 195, at 277.

[248] LUKE A. STEWART, INFO. TECH. & INNOVATION FOUND., THE IMPACT OF REGULATION ON INNOVATION IN THE UNITED STATES: A CROSS-INDUSTRY LITERATURE REVIEW 8 (2011) (citing Porter & van der Linde, *supra* note 22, at 168).

[249] *See* Porter & van der Linde, *supra* note 22, at 120, 122, 125–26 (using real-world examples to prove that regulation can push companies into producing higher-quality products and, subsequently, increase profits).

[250] *Id.*

[251] *Id.*

their use of harmful resources and cut costs faster than their competition.[252] Similarly, reducing the negative environmental impact of products can increase the quality of those products.[253] Such a reduction enhances the desirability of such a product as consumers increasingly demand more environmentally friendly products.[254] To gain the attention of this growing class of consumers, companies compete to produce products with the least impact on the environment.[255]

As a relatively new theory, some scholars remain critical of the PH. Some critics have focused their commentary on theoretical disagreements with the PH.[256] This group most commonly finds fault with the PH's claim that companies periodically fail to capitalize on advantageous innovations that are technologically available.[257] More specifically, they criticize the PH because it is incompatible with the theory that companies are profit-maximizing and will therefore always take action that will increase their profits.[258] According to the profit-maximization theory, regulation is never necessary to motivate companies to implement innovations that will increase profits.[259] The PH addresses this critique by arguing that regulation can spur innovation because in reality, unlike pure theory, not all companies exclusively make the best possible choices for increasing profits—humans make mistakes.[260]

Further, economists and researchers have compiled significant empirical evidence regarding whether the PH's claims are true. The vast majority of evi-

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[252] *See id.* at 120, 125–26, 128–31 (discussing examples where regulation forced companies to make changes that ultimately cut costs for the companies).

[253] *See id.* at 132–33 (using the example of refrigerators in Germany during the 1990s to illustrate this concept).

[254] *See id.* at 120 (discussing the idea of a "green" premium and how customers are willing to pay it); Porter & van der Linde, *supra* note 21, at 104 (discussing the changing markets and the emerging demand for green products); Gary Drenik, *Eco-Conscious Buyers Are Shifting Consumer Trends, Here's How Retailers Are Responding*, FORBES (Sept. 13, 2022), https://www.forbes.com/sites/garydrenik/2022/09/13/eco-conscious-buyers-are-shifting-consumer-trends-heres-how-retailers-are-responding/?sh=5f045fbc7449 [https://perma.cc/H5Q4-DP5T] (explaining that company-led customer surveys have revealed the "green" interests of customers).

[255] *See* Michael Faure, *Effectiveness of Environmental Law: What Does the Evidence Tell Us?*, 36 WM. & MARY ENV'T L. & POL'Y REV. 293, 299 (2012) (explaining that environmental quality leads to economic growth on a national level); Porter & van der Linde, *supra* note 21, at 104–05 (discussing the economic boon granted to "early-movers" who make environmental changes early); Porter & van der Linde, *supra* note 22, at 120, 127 (explaining that companies have been able to raise prices as a so-called green "premium" for their environmental efforts).

[256] *See, e.g.*, Michael A. Livermore, *The Meaning of Green Growth*, 3 MICH. J. ENV'T & ADMIN. L. 33, 56 & n.115 (2013) (citing Karen Palmer, Wallace E. Oates & Paul R. Portney, *Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm?*, 9 J. ECON. PERSPS. 119, 120–21 (1995)) (laying out that some critics find this tenet of PH to directly conflict with rational business operations and that some studies reveal regulation decreases efficiency).

[257] *Id.* at 56.

[258] *Id.*

[259] *Id.*; AMBEC ET AL., *supra* note 20, at 5.

[260] Porter & van der Linde, *supra* note 21, at 99.

dence support the PH's claims.[261] For example, a group of researchers analyzed the validity of the PH's claims twenty years after the hypothesis was published.[262] After reviewing empirical data of environmental regulations, they concluded that the PH's claims "are now more solid than they appeared at first."[263] And there are many real-world examples of the PH successfully working, as the next Section describes.[264]

B. The Porter Hypothesis in Action: Examples of Success

The PH indicates that if crypto miners are properly incentivized, they can develop innovations that reduce the industry's environmental harm.[265] Although crypto miners will likely oppose regulations, there is a long history of businesses innovating in order to comply with regulations and incidentally creating a solution that is both green and cost-saving.[266] Porter and van der Linde provide several examples of environmental regulation that stimulates innovation.[267]

In the 1990s, the government promulgated several new regulations that required many manufacturers and users of solvents (which are used to coat paper, plastic, and metal) to reduce their solvent emissions by ninety percent.[268] These regulations focused on reducing environmental harm and maximized the opportunity for innovation by providing the polluters several years to comply with the regulations.[269] This gave polluters adequate time to R&D innovative, win-win solutions.[270] For example, 3M[271] "responded by avoiding

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[261] Noah M. Sachs, *Can We Regulate Our Way to Energy Efficiency? Product Standards as Climate Policy*, 65 VAND. L. REV. 1631, 1663–64 (2012) (citing HERMAN R.J. VOLLEBERGH, DIFFERENTIAL IMPACT OF ENVIRONMENTAL POLICY INSTRUMENTS ON TECHNOLOGICAL CHANGE: A REVIEW OF THE EMPIRICAL LITERATURE 19–20 (2007)); AMBEC ET AL., *supra* note 20, at 16.

[262] *See* AMBEC ET AL., *supra* note 20, at 16 (listing the results of the study).

[263] *Id.* Though much of the evidence regarding the PH's claims has been positive, some evidence has been more negative. *See* Livermore, *supra* note 256, at 56 & n.116 (first citing Eli Berman & Linda T.M. Bui, *Environmental Regulation and Productivity: Evidence from Oil Refineries*, 83 REV. ECON. & STAT. 498, 498–99 (2001); then citing Andrew A. King & Michael J. Lenox, *Does It* Really *Pay to Be Green?: An Empirical Study of Firm Environmental and Financial Performance*, 5 J. INDUS. ECOLOGY 105 (2001); and then citing Stephen M. Meyer, *The Economic Impact of Environmental Regulation*, 3 J. ENV'T L. & PRAC. 4 (1995)) (listing contrasting viewpoints).

[264] *See infra* notes 265–283 and accompanying text.

[265] *See* Porter & van der Linde, *supra* note 21, at 98 (suggesting regulation as a means of incentivizing innovation).

[266] *Id.* at 102–03.

[267] *Id.*

[268] *Id.* at 103.

[269] *Id.*

[270] *Id.*

[271] Matthew Johnston, *How 3M Makes Money*, INVESTOPEDIA, https://www.investopedia.com/articles/markets/022015/how-3m-makes-its-money.asp [https://perma.cc/MM57-ZJU4] (June 29, 2023) (describing various aspects of 3M Co.'s financials and business operations). 3M manufactures and distributes a range of products, including building materials and cleaning supplies. *Id.*

the use of solvents altogether and developing coating products with safer, water-based solutions."[272] At just one of 3M's plants, this change reduced air emissions by 24 tons per year.[273] The change cost the plant $60,000 up-front, but ultimately saved them "$180,000 in unneeded pollution control equipment and created annual savings of $15,000 in solvent purchases."[274] The change also provided 3M with "an early-mover advantage in product development over competitors"[275] and allowed it to avoid the lengthy regulatory approval process required for solvent-based coatings.[276]

Regulation also "can stimulate new entrants to introduce *entirely new products and processes* into the market—products and processes that will displace dominant technologies."[277] Specifically, regulations with strict pollution standards that ban or greatly reduce the use of a harmful pollutant, and do not allow secondary treatment, can attract new entrants to the industry because entirely new innovations are often needed—updating older methods is often not sufficient for compliance.[278] Thus, companies who otherwise are not involved with the regulated industry have an opportunity to create innovative solutions and use it as leverage to enter the market.[279]

This phenomenon happened when the Toxic Substances Control Act (TSCA) banned the use of polychlorinated biphenyls (PCBs).[280] The statutory ban resulted in Dow Silicone, a new entrant to the market, completely displacing Monsanto's use of PCBs in transformers and capacitators by successfully implementing a different dielectric fluid.[281] This switch was enormously important for the environment, as the presence of PCBs in Monsanto's products caused extensive environmental contamination.[282] It also increased the oppor-

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[272] Porter & van der Linde, *supra* note 21, at 103.

[273] *Id.*

[274] *Id.*

[275] Porter & van der Linde, *supra* note 22, at 126.

[276] *Id.*

[277] Ashford & Hall, *supra* note 195, at 279.

[278] *See id.* (explaining that room for innovation acts as an invitation to firms looking for an inroads within an industry).

[279] *See id.* (stating that companies within an industry fear these kinds of new entrants, explaining why they are so resistant to regulation).

[280] *See Learn About Polychlorinated Biphenyls*, EPA, https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls [https://perma.cc/BX2H-CBNA] (stating that polychlorinated biphenyls were manufactured from 1929 to 1979, at which time the Toxic Substances Control Act banned the substance).

[281] Ashford & Hall, *supra* note 195, at 279.

[282] Jonathan Stempel, *Los Angeles County Sues Bayer's Monsanto Over PCB Contamination*, REUTERS (May 30, 2019), https://www.reuters.com/article/us-bayer-lawsuit-los-angeles/los-angeles-county-sues-bayers-monsanto-over-pcb-contamination-idUSKCN1T02DJ/ [https://perma.cc/D2UM-LSH6].

tunity for innovation and spurred competition by creating an opening in the market that attracted new players to the market.[283]

C. Expected Benefits to Crypto Mining from Applying the Porter Hypothesis and the Proposed Regulatory Program

Currently, crypto miners are generally not competing to win customers by reducing their environmental impact because there are no regulations that directly address crypto mining's harm.[284] If, for example, regulations taxed crypto miners based on their GhG emissions, miners would then focus on reducing their emissions and, thus, their environmental impact, as this would reduce their expenses.[285] In turn, this would incentivize competition to reduce tax expenses and adopt the technological solutions that best limit pollution and minimizes costs.[286]

IV. Proposed Solutions: Using the Porter Hypothesis to Design Environmental Regulations That Encourage Innovation and Competition

This Part proposes a regulatory program for crypto[287] based on the principles of the PH, as the previous Part explained. The regulatory solutions, like the explanation of the principles, are ordered into three categories: process, substance, and implementation. Section A discusses the first principle—the process of creating regulations.[288] Section B then explains what the substance of the regulations must contain.[289] Lastly, Section C highlights the ideal manner of implementing the regulations.[290]

Beginning with the regulatory process, the PH directs that the process should be knowledgeable, consultative, and cooperative; this Part explains how these suggestions should be implemented in the specific context of regulating crypto mining.[291] For example, policymakers should understand the technical

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[283] Ashford & Hall, *supra* note 195, at 279.

[284] *See supra* Part II (explaining the lack of environmentally based regulations of the crypto industry, despite its enormous energy usage).

[285] *See* Porter & van der Linde, *supra* note 21, at 98 (arguing that environmental regulations force companies to use their resources more efficiently, thereby saving companies money).

[286] *See id.* (stating that profit-seeking companies do not always choose the most efficient route in running their business, but regulation could push them in this direction to avoid the costs of regulation).

[287] *See infra* notes 294–516 and accompanying text. This Article's proposed program could be part of a package of new legislation to address the other crypto-related issues like consumer fraud and financial risks.

[288] *See infra* notes 294–352 and accompanying text.

[289] *See infra* notes 353–449 and accompanying text.

[290] *See infra* notes 450–516 and accompanying text.

[291] *See infra* notes 294–516 and accompanying text.

elements of crypto mining as that knowledge base will result in regulations that better encourage innovation and competition for all miners.

As for substance, the PH's principles indicate a program that provides miners with flexibility in choosing how they satisfy emission limits, while incentivizing them to do so through the use of a market incentive—like a cap-and-trade program or a pollution tax, which, as explained below, is a better tool for incentivizing innovation from crypto miners. The PH's principles also encourage product and process changes that reduce pollution at its source, not just treat the pollution after the fact. The program should also fund pilot projects to demonstrate to miners how to find innovative ways to reduce their environmental footprint. For example, such a program could demonstrate ways to connect to more renewable energy sources, so miners can use those sources more consistently.

Lastly, for implementation, the regulations should include phase-in periods, such as an eighteen-month period in which the emissions threshold for a pollution tax is gradually increased, or phased in, until the final threshold standard is implemented. The regulations should also set deadlines that are realistically achievable; specific time horizons will be easier to gauge once regulators obtain a better understanding of crypto mining and consult with miners. Regulators should gather and disseminate information about pollution caused by crypto miners. This will empower regulators to track compliance and effectiveness of the regulatory program, allow consumers to choose based on environmental friendliness, and push companies to compete to be "greener" than one another. Finally, regulators should strive for regulatory stability and avoid uncertainty—this could mean a commitment to five years without regulatory changes.

As explained in Part II.A, legislation providing legal authority for environmental regulations typically grants authority to an agency, sets broad goals (e.g., to reduce the amount of pollution in the air (CAA), or, in the case of crypto, to reduce energy usage by miners), and then instructs that agency to promulgate specific rules and standards to meet those goals. Typically, legislation leaves the details of those rules and standards—for example, the quantity of a GhG emissions limit—to the agency.[292] Legislation following this Article's proposed regulatory program for crypto mining should follow a similar route. Specifically, legislators should enact a law that authorizes environmental regulations of crypto mining and gives the EPA authority to issue rules and standards. Then, the EPA should develop the specific rules and standards. For example, legislators should choose which market incentive to use (a tax or cap-

[292] *See supra* notes 151–155 and accompanying text.

and-trade program), but then allow the agency to implement the details, such as when the tax will go into effect.

The following discussion of the proposal will state whether each suggestion is for legislators or regulators.[293] The discussion uses the term "policymakers" when the proposed action is aimed at both legislators and regulators.

A. Process: Knowledge, Consultation, and Alignment

The PH suggests three main principles about the regulatory process: to regulate based on thorough knowledge of the regulated industry, to consult with the regulated industry early and often, and to approach regulation with a cooperative rather than adversarial stance.[294] Subsection 1 explains that, in regulating crypto, "improving knowledge" would include gaining a sound understanding of crypto generally and crypto mining technology, as well as the economics and competitive dynamics of the industry.[295] Subsection 2 explains why policymakers should also solicit input from the crypto industry, seeking substantive feedback on early drafts of proposed regulations, such as the length of deadlines and phase-in periods.[296] Subsection 3 discusses the final process suggestion for policymakers: to take a cooperative, rather than adversarial, stance toward crypto miners—such as publicly praising those companies that are "going green," or directly conveying to miners how their economic interests align with the environmental interests of policymakers.[297]

1. Knowledge: Improve Regulators' Understanding of the Industry Before Regulating

Prior to drafting any regulations, the PH recommends policymakers improve their understanding of the regulated industry.[298] Specifically, they must study and understand the economics of the regulated industry.[299]

For crypto regulations, policymakers should understand how crypto miners make money under PoW and other consensus mechanisms, the industry's financial risks, miners' biggest expenses, and the factors driving competition within crypto mining. They should also understand the technical side of mining, including how PoW and PoS work, as well as the mechanisms' security benefits and downsides.

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[293] *See infra* notes 294–516 and accompanying text.
[294] Porter & van der Linde, *supra* note 22, at 124.
[295] *See infra* notes 298–313 and accompanying text.
[296] *See infra* notes 314–329 and accompanying text.
[297] *See infra* notes 330–352 and accompanying text.
[298] Porter & van der Linde, *supra* note 22, at 124.
[299] *Id.*

Policymakers armed with this information will be able to adopt higher-quality regulations, because they will better understand how to craft legislation and regulations that will encourage innovation, competitiveness, and a focus on resource productivity. This is especially true of regulators, who will likely be the ones promulgating the details of the rules and standards.[300] Policymakers lacking such awareness are at an increased risk of promulgating rules that burden, rather than optimize, the efficiency of the industry.[301]

For example, the drafters of the DAME Tax likely failed to understand that their proposal would not lead to innovation because it penalizes miners for all energy usage rather than incentivizing movement toward using more renewable energies.[302] Further, the authors of the OSTP report do not appear to have knowledge of the competitiveness or economics of crypto mining—the report fails to discuss either of these topics.[303] Additionally, the recommendations themselves make this lack of understanding clear as their solutions would harm both the competitiveness of domestic crypto miners and miners' profits.[304]

The PH also recommends that policymakers gain knowledge about the cluster of suppliers, consumers, and upstream and downstream industries involved in crypto mining.[305] According to the PH, policymakers armed with a broad base of knowledge of the industry "will foster fundamental rather than piecemeal solutions"—that is, solutions that reduce pollution instead of focusing on secondary treatment of pollution.[306]

As this recommendation relates to crypto mining, policymakers should gain understanding of miners' energy suppliers. Specifically, they should investigate whether renewable energy suppliers are near most major mining operations. Further, they should assess whether those renewable energy suppliers can provide enough energy for miners.

It would also be helpful for policymakers to have some understanding of the downstream consumers and users of crypto coins—the markets for crypto miners' product. Specifically, they should consider whether those people and entities care about the environmental footprint of crypto coins, and whether it

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[300] *See id.* at 120, 124 (discussing the importance of lawmakers educating themselves in the field for which they are crafting regulations).

[301] *Id.*

[302] *See generally The DAME Tax: Making Cryptominers Pay for Costs They Impose on Others*, *supra* note 13.

[303] *See generally* WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *supra* note 100 (failing to discuss the competitiveness or economics of crypto mining).

[304] *See generally id.* (failing to show any concern for the potential impacts of regulation on the growth and competitiveness of the industry as a whole).

[305] Porter & van der Linde, *supra* note 21, at 111.

[306] *See id.* (explaining the need to avoid "end-of-pipe" solutions and secondary treatment due to their reactionary nature).

is possible to get them to care more. Over the last several decades, consumer consciousness of and preference for environmentally friendly products have drastically risen.[307]

Understanding this issue should help policymakers in their approach to regulations. For example, if it turns out that a significant percent of crypto users do care about using "green-mined" coins, regulators could appeal to this interest by establishing an eco-label or certification for those coins. In fact, the PH recommends that regulators establish such programs to raise awareness of and help spur demand for greener products.[308] U.S. agencies have a track record of establishing eco-labels,[309] like "Energy Star" certification for appliances,[310] that have also helped spur demand for environmentally friendly products, processes, and innovations.[311] Thus, regulators could consider establishing a similar program for crypto.[312]

The PH's suggestion that policymakers increase their knowledge about crypto mining complements and overlaps with the next suggestion discussed in this Article—encouraging industry participation early in the formulation of regulations.[313]

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[307] *See* Sherry Frey et al., *Consumers Care About Sustainability—and Back It Up with Their Wallets*, MCKINSEY & CO. (Feb. 6, 2023), https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/consumers-care-about-sustainability-and-back-it-up-with-their-wallets [https://perma.cc/B2ZE-ZEG4] (discussing the trend of appealing to customers' growing interest in environmentally friendly and sustainable products).

[308] Porter & van der Linde, *supra* note 21, at 112.

[309] *Buying Green for Consumers*, EPA, https://www.epa.gov/greenerproducts/buying-green-consumers [https://perma.cc/ZKE6-5AC6] (June 20, 2023); *see* Sasha Stashwick, *Buy Clean Takes Center Stage at U.S. DOT and Other Agencies*, NAT. RES. DEF. COUNCIL (Sept. 15, 2022), https://www.nrdc.org/bio/sasha-stashwick/buy-clean-takes-center-stage-us-dot-and-other-agencies [https://perma.cc/J7PB-3QJH] (explaining the Buy Clean effort implemented by the Biden Administration and the various policies of which the plan consists); Press Release, The White House, Biden-Harris Administration Announces New Buy Clean Actions to Ensure American Manufacturing Leads in the 21st Century (Sept. 15, 2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/09/15/fact-sheet-biden-harris-administration-announces-new-buy-clean-actions-to-ensure-american-manufacturing-leads-in-the-21st-century/ [https://perma.cc/8XRQ-M8DK] (announcing the White House's Buy Clean initiative).

[310] *ENERGY STAR Certification*, ENERGY STAR, https://www.energystar.gov/about/how-energy-star-works/energy-star-certification [https://perma.cc/DNY6-BMGR].

[311] Porter & van der Linde, *supra* note 21, at 112.

[312] *See infra* notes 483–496 and accompanying text (suggesting that regulators collect information on miners' emissions). Establishing such a program would require few extra resources.

[313] *See* Porter & van der Linde, *supra* note 22, at 124; *infra* notes 314–329 and accompanying text.

2. Consultation: Involve the Industry in Dialogue Early in the Legislative and Regulatory Processes

After policymakers improve their knowledge of the industry, they should then approach regulation as a dialogue by soliciting industry input early and often in the legislative and regulatory processes. The PH explains that substantive industry participation in setting environmental regulations is helpful throughout these processes.[314]

Based on the PH's suggestions, legislators should request crypto miners' participation while they draft legislation, and the agency delegated to develop specific standards should ask for industry participation in the process. Miners should help with specifics, like the content of regulations and the timing of when those regulations go into effect.[315] Per the PH, this process could start with legislators drafting and sending a set of information requests to the major crypto mining companies,[316] similar to Senator Warren's letter about crypto miners' energy usage.[317] This would provide Congress and the agency with more data about the industry's current mining situation and with more insight as to how best to regulate the industry.[318] For example, information requests could include: renewable energy usage; reasons why the industry is not using more renewable energies; areas of their mining business that they think could be improved upon through innovation; and possible technological developments that could occur in the near future.

Per the PH, Congress should also meet with industry representatives while drafting proposed legislation to get industry feedback over specific aspects of proposed legislation.[319] Congress could do this via formal hearings or informal meetings. Informal meetings would likely be viewed as less adversarial and, thus, result in more high-quality information. Then, legislators should ask miners to give detailed feedback, in those interactions or in written responses, as Congress considers early versions of proposed legislation.[320]

Regarding miners' interaction with the regulators at the designated agency, the Administrative Procedure Act requires agencies to provide the public

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[314] Porter & van der Linde, *supra* note 21, at 113.

[315] Porter & van der Linde, *supra* note 22, at 124.

[316] *Id.*

[317] *See generally* Letter from Sen. Elizabeth Warren to Jeffrey Kirt, *supra* note 140.

[318] *See* Porter & van der Linde, *supra* note 22, at 124 (introducing the idea that lawmakers should focus on gathering data before writing new regulations for an industry).

[319] *See id.* (discussing the importance of industry involvement in drafting regulations given their technical knowledge and experience).

[320] *See id.* (explaining that industry involvement can give legislators a better idea as to whether or not their regulation approaches an issue in a meaningful and realistic manner).

with adequate notice of a proposed rule.[321] Once adequate notice is provided, the agency must provide interested persons with a meaningful opportunity to comment on the proposed rule.[322] Although such comments from miners may prove to be helpful, the regulators should continue to involve miners in dialogue beyond this notice-and-comment period.[323]

One option for regulators to consider is to use their authority under the Negotiated Rulemaking Act to establish a committee comprised of regulators, industry, and environmentalists to negotiate proposed environmental regulations with the industry.[324] The designated agency should consider establishing such a committee and engaging in the negotiated rulemaking. After establishing such committees and successfully negotiating environmental rules, U.S. agencies have explained that the resulting benefits of negotiated rulemaking include: increasing compliance; saving resources; building cooperation; increasing regulatory certainty, which allows better planning for industry; and reducing litigation and contentiousness after the regulations have been promulgated.[325] Each of these benefits is relevant to environmental regulations for crypto miners, as they would lead to increased innovation within the industry and they align with the PH's principles.

Early, high-quality participation from miners will improve the effectiveness of the legislation and regulations to curb pollution, while also encourag-

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[321] 5 U.S.C. § 553. Generally, when an agency promulgates legislative rules, or rules made pursuant to congressionally delegated authority, the exercise of that authority is governed by the informal rulemaking procedures outlined in 5 U.S.C. § 553. *See id.* (prescribing the rulemaking procedures for U.S. agencies).

[322] *Id.* § 553(c).

[323] *See* Porter & van der Linde, *supra* note 21, at 113 (stressing the importance of continued cooperation); Porter & van der Linde, *supra* note 22, at 124 (same).

[324] *See generally* 5 U.S.C. §§ 561–570 (consisting of the Negotiated Rulemaking Procedure statutes). Negotiated rulemaking represents a supplement to traditional informal rulemaking procedures that allows agencies to consult with interested parties at the developmental stages of the rulemaking process. *Id.* § 561. Negotiated rulemaking allows the agency and other involved interests to reach consensus in the early rulemaking stages to produce rules that are more likely to be acceptable to all parties. *See id.* § 566 (discussing the committee's function). Under the Negotiated Rulemaking Act, the head of an agency is authorized to "establish a negotiated rulemaking committee to negotiate and develop a proposed rule, if . . . the use of the negotiated rulemaking procedure is in the public interest." *Id.* § 563(a). The negotiated rulemaking committee generally consists of a maximum of twenty-five members with at least one agency representative. *Id.* § 565(b). If the committee achieves consensus on a proposed rule, the committee issues a report outlining the proposed rule. *Id.* § 566(f). If the committee does not achieve a consensus, the committee may issue a report with any negotiated positions on which it did reach consensus. *Id.* Any proposed rule that arises from the deliberations of a negotiated rulemaking committee must subsequently "be finalized through ordinary notice-and-comment procedures." 1 CHARLES H. KOCH JR., ADMINISTRATIVE LAW AND PRACTICE § 4:36 (3d ed. 2010).

[325] AGRIC. MKTG. SERV., U.S. DEP'T OF AGRIC., WHAT IS NEGOTIATED RULEMAKING? 3, https://www.ams.usda.gov/sites/default/files/media/Feb82011IntrotoNR.pdf [https://perma.cc/NSH2-UDGU].

ing innovation, competition, and a focus on resource productivity.[326] This is because industry will have special insight into ways to encourage innovation, competition, and resource productivity.[327] Such insights might be ones that policymakers would otherwise miss.[328] Further, miners will have the opportunity to question proposed rules that are not clear, would unnecessarily hinder operations, or thwart their ability to innovate and compete.[329]

Moreover, early industry participation will help miners innovate because through their participation and interaction with policymakers, they will have a better understanding of what regulations are coming. Thus, they will have an idea in advance of how they will need to innovate to reduce their environmental harm to be compliant.

3. Alignment: Take a Cooperative Stance Toward Crypto Miners and Convince Them That Their Economic Interests Align with the Environmental Interests of Regulators

As the PH suggests, legislators and regulators should avoid viewing crafting and implementing crypto mining environmental regulations through an adversarial process.[330] Instead, they should view this process as a collaboration with miners and proceed on the premise that cooperative regulation can benefit the industry by increased competition and profitability; to aid this, the cooperation should be made known to both the industry and the public.[331]

In the United States, pro-environment legislators and environmental regulators often have an adversarial relationship with industries.[332] In fact, battles over environmental regulations are the norm in U.S. public policy.[333] This pattern has so far repeated itself with crypto mining. Legislators, the EPA, and the Biden Administration have already established an adversarial relationship with crypto miners by effectively claiming that the industry's emission habits pose an environmental crisis.[334] For example, in a letter to members of Congress,

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[326] Porter & van der Linde, *supra* note 21, at 113; Porter & van der Linde, *supra* note 22, at 124.

[327] Porter & van der Linde, *supra* note 21, at 113; Porter & van der Linde, *supra* note 22, at 124.

[328] Porter & van der Linde, *supra* note 21, at 113; Porter & van der Linde, *supra* note 22, at 124.

[329] *See* AGRIC. MKTG. SERV., *supra* note 325, at 3 (discussing the many advantages of negotiated rulemaking, including increasing cooperation and communication between the two sides).

[330] *See* Porter & van der Linde, *supra* note 22, at 125–26, 133–34 (explaining the potential benefits of industry and regulators working together and that their interests are aligned, as well as the potential pitfalls if the two sides resist each other).

[331] *Id.*

[332] *Id.*

[333] *Id.* at 134.

[334] *See, e.g.*, *Cleaning up Cryptocurrency: The Energy Impacts of Blockchains*, *supra* note 143 (illustrating the House of Representatives' awareness of the crypto industry's energy consumption and the problems it poses).

the EPA called the environmental harms caused by crypto mining a "crisis."[335] Instead of using such rhetoric, policymakers should acknowledge the harms, but communicate to the industry that a collaborative approach to environmental reform can also put the industry on better economic footing.

Further, an adversarial stance toward crypto miners is unnecessary because regulators' goals actually align with the industry's goals in the modern business landscape.[336] Today, innovation and resource productivity are critical to a company's competitiveness and success.[337] In the modern economy, the most competitive companies are those that use the most advanced technology and practices to productively use their resources.[338] Further, because technology is constantly changing, the new paradigm of global competitiveness requires the ability to innovate rapidly.[339] Conversely, a company that does not focus on improving its resource productivity quickly loses any competitive edge.[340] At the same time, "[e]nvironmental progress demands that companies innovate to raise resource productivity."[341] Thus, the modern business landscape brings environmental improvement, innovation, and resource productivity together.[342]

According to the PH, the change in what is required for a company to succeed "has profound implications for the debate about environmental policy—about how to approach it, how to regulate, and how strict regulation should be."[343] Specifically, given that modern competition demands that companies focus on resource productivity, which also decreases a company's environmental impact, policymakers' goals align with miners' goals.[344] For example, the most expensive cost for the majority of crypto miners is energy usage.[345] Therefore, when miners improve energy efficiency, they also cut costs—thus reducing emissions and increasing profit. Further, if U.S. environmental regulations made American crypto miners more energy-efficient, they would then gain a competitive advantage over crypto miners in other countries.

Policymakers could communicate that PoW miners, through their voracious appetite for energy, could in fact make renewable energies more accessible for all energy consumers while also making renewables more reliable and

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[335] Lee, *supra* note 144.
[336] Porter & van der Linde, *supra* note 22, at 125–27, 133–34.
[337] *Id.*
[338] *Id.*
[339] *Id.* at 125–28.
[340] *Id.*
[341] *Id.* at 133.
[342] *Id.*
[343] *Id.*
[344] *Id.* at 125–28.
[345] Jake Frankenfield, *What Is Bitcoin Mining?*, INVESTOPEDIA, https://www.investopedia.com/terms/b/bitcoin-mining.asp [https://perma.cc/7VFZ-NELM] (Oct. 11, 2023).

cheaper.[346] This would make more renewable energies accessible not only for crypto miners, but also for other energy consumers.[347] If true, policymakers should communicate this to the public and emphasize how miners are improving the accessibility, reliability, and cost of renewable energies for all and, therefore, improving the environment. This would reduce the adversarial nature of the policymaker-industry relationship and would portray crypto miners in a positive light to the public, rewarding them for cooperating with policymakers' environmental goals.

As noted above, in the United States, battles between policymakers and industries over environmental regulations are the norm.[348] In fact, it is common for industries to resist environmental regulations by expending millions of dollars worth of resources to delay and weaken the regulations.[349] Once policymakers replace their adversarial stance for a cooperative one, the crypto industry may be less likely to fight the regulations through lobbying and litigation. Even if opposition is not totally defused, at the margins, some industry players might be more receptive and less opposed to the program of regulation.

When companies use resources to fight regulations, companies are essentially rerouting resources that could have been used for environmentally friendly solutions to costly litigation, lobbying, and compliance through secondary treatment, none of which improves the environment.[350] If policymakers take a more collaborative approach, however, they will likely help reduce—though not completely solve—such regulatory battles.[351] In turn, this will al-

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[346] *The Role of Bitcoin Mining in Renewables Projects*, DLA PIPER (Feb. 21, 2023), https://www.dlapiper.com/en-gb/insights/publications/2023/02/the-role-of-bitcoin-mining-in-renewables-projects [https://perma.cc/MN7K-X5YN]. Some Bitcoin enthusiasts claim that as PoW cryptos grow in prevalence, renewable energy infrastructure will also grow to fuel their mining operations. *Id.* This growth in infrastructure will then grant other consumers access to renewable energies to power their needs. *Id.* PoW mining also has the potential to expand the use of renewable energies because "[r]enewable energy currently struggles with reliability, cost[,] and use of electricity throughout American power grids. [But] Bitcoin mining provides a solution to each of these issues." Dennis Porter, Opinion, *Bitcoin Mining Is Good for the Energy Grid and Good for the Environment*, COINDESK, https://www.coindesk.com/consensus-magazine/2023/03/06/bitcoin-mining-is-good-for-the-energy-grid-and-good-for-the-environment/ [https://perma.cc/CSS9-WGH3] (Mar. 6, 2023).

[347] *See* Porter, *supra* note 346 (arguing that the massive energy demands of the crypto industry will inevitably lead to the expansion of renewable energy).

[348] *See* Porter & van der Linde, *supra* note 22, at 133 (using the U.S. car industry as a paramount example of companies being left behind by competition more receptive to regulation).

[349] *Id.*

[350] *Id.* at 128 (citing Jan Paul Acton & Lloyd S. Dixon, *Superfund and Transaction Costs: The Experiences of Insurers and Very Large Industrial Firms* (Rand Inst. for Civ. Just., Working Paper No. 4132, 1992)).

[351] *See id.* at 126 (discussing the success of companies when they work with, rather than against, regulators).

low miners to use some of those saved resources to develop innovative solutions to their emission problems.[352]

B. Regulatory Substance: Use Market Incentives, Provide Technological Flexibility, Focus on Reducing Primary Harm, and Fund Pilot Programs

This Section discusses the different tools policymakers should use when designing the substance of crypto regulations and what kind of mechanisms the regulations should contain.[353] Subsection 1 warns against the use of fixed technology standards and promotes more flexible alternatives.[354] Subsection 2 champions primary, at-the-source solutions over the reactive secondary treatment solutions currently used in the United States.[355] Then, Subsection 3 discusses the need for government funding programs to spur innovation and demonstrate results.[356]

1. Promote Flexible Approaches to Harm Reduction by Using a Market-Based Incentive and Not Mandating Use of Specific Technologies

The PH indicates that regulators should *not* mandate that companies use a specific technology to comply with environmental regulations.[357] Instead, regulators should set standards and allow the industry flexibility in satisfying those standards by using a market incentive, like a pollution tax or a cap-and-trade program.[358] Essentially, regulators should "leav[e] the approach to innovation to industry and not the standard-setting agency."[359]

a. Providing Technological Flexibility to Miners in Deciding How to Satisfy Environmental Standards

The PH states that regulators should set standards but let the industry decide what technologies to use to meet those standards.[360] Unfortunately, mandating the use of a particular technology to satisfy an environmental regulation is a deeply rooted technique in the United States.[361] Generally, under that style

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[352] *See id.* (explaining that when regulators push companies to comply with regulations, the companies respond with greener solutions that did not previously exist).

[353] *See infra* notes 357–449 and accompanying text.

[354] *See infra* notes 357–421 and accompanying text.

[355] *See infra* notes 422–437 and accompanying text.

[356] *See infra* notes 438–449 and accompanying text.

[357] Porter & van der Linde, *supra* note 21, at 110–11; Porter & van der Linde, *supra* note 22, at 124.

[358] Porter & van der Linde, *supra* note 21, at 111.

[359] *Id.* at 110.

[360] *Id.* at 110–11; Porter & van der Linde, *supra* note 22, at 124.

[361] Porter & van der Linde, *supra* note 22, at 124.

of regulation, the regulatory agency identifies a technology that is easily achievable and then requires polluters to utilize technology of equal capabilities.[362]

According to the PH, legislating in this manner "almost guarantees that innovation will not occur."[363] Requiring the use of a specific technology encourages a static mindset and discourages further innovation beyond the prescribed technology.[364] More specifically, setting standards based on a mandated technology that already exists does not incentivize innovation because the polluters may comply by merely adopting current technologies.[365] Furthermore, there is no incentive to invest resources to develop innovations that reduce pollution beyond current limits.[366]

Conversely, if regulators promulgate the environmental standards, but remain agnostic about the technology used to comply with those standards, they will successfully encourage innovation.[367] This approach gives the polluter the freedom to develop methods to satisfy the environmental standards; companies are no longer locked into a static mindset and are free to innovate however fits them best.[368]

In the context of crypto, a mandated technology approach might look like requiring miners to use PoS rather than PoW—in other words, banning PoW mining. Given the successful use of PoS mining, especially Ethereum's successful switch from PoW to PoS mining in 2022,[369] some policymakers will likely consider mandating that all crypto mining operations use PoS mining. In fact, the White House's OSTP's letter urged Congress to consider legislatively banning consensus mechanisms like PoW mining.[370] Congress should not legislatively ban PoW, and regulators should not mandate the use of PoS mining, however, because this would have all the drawbacks of the "mandating" ap-

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[362] *Learn About Effluent Guidelines*, EPA, https://www.epa.gov/eg/learn-about-effluent-guidelines [https://perma.cc/68RN-KQ22] (Aug. 31, 2023); Porter & van der Linde, *supra* note 21, at 110–11.

[363] Porter & van der Linde, *supra* note 21, at 111.

[364] *Id.* at 110–11; Porter & van der Linde, *supra* note 22, at 124.

[365] *See* Sangeeta Bansal & Shubhashis Gangopadhyay, *Incentives for Technological Development: BAT Is Bad*, 30 ENV'T & RES. ECON. 345, 360 (2005) (discussing the downside of technology mandates and their promotion of a certain level of stagnation rather than progression).

[366] *See* Faure, *supra* note 255, at 307 (stating "industry will not adopt cleaner technologies if the regulator announces a policy which is based on [mandating the use of a specific technology]" (citing Bansal & Gangopadhyay, *supra* note 365, at 360)).

[367] *Id.* (quoting Bansal & Gangopadhyay, *supra* note 365, at 345–46, 358–59).

[368] *See id.* (explaining that regulations without technology mandates encourage firms to develop new technology to comply with the regulations in a cheap and efficient manner).

[369] Nina Bambysheva, *Ethereum Merge Complete, $195 Billion Cryptocurrency Begins New Era*, FORBES (Sept. 15, 2022), https://www.forbes.com/sites/ninabambysheva/2022/09/15/ethereum-merge-complete-195-billion-cryptocurrency-begins-new-era/?sh=4299208330a8 [https://perma.cc/N345-R5JZ].

[370] WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *supra* note 100, at 7.

proach just noted.[371] Instead, as the PH explains, regulators should focus on encouraging their desired outcomes—reducing environmental harms—rather than the technological means to achieve those results.[372]

b. Implementing Market-Based Regulatory Mechanisms to Promote Flexibility

Similarly, in accordance with the PH, policymakers should provide miners with flexibility to satisfy regulatory standards through the use of a market-based regulatory instrument, like a pollution tax or a cap-and-trade program.[373] Such regulatory instruments encourage polluters to reduce or eliminate their emissions by penalizing companies financially when they do pollute.[374] At the same time, these market incentives provide polluters flexibility in deciding how to reduce their pollution.[375] Essentially, policymakers provide industry flexibility by replacing a mandatory approach with a market-based approach.[376] Although setting emissions levels before the market incentives begin to tax the miner is acceptable, the more ideal policy would be to tax all emissions.[377]

Legislators should implement only one of these market incentives; administering both would require more government resources and would be politically difficult as it would appear to hamper the industry's ability to compete globally. Additionally, implementing both measures would be difficult, if not impossible, as they would conflict with each other at times.

This Subsection will discuss both of these market incentives as they are the best market-based regulatory mechanisms for crypto mining.[378] If implemented in concert with the other suggestions discussed in this Article, either incentive should reduce environmental degradation and encourage both innovation and competition. As discussed in Subsection ii, however, a pollution tax that taxes all GhG emissions would be the most faithful to the PH's principles.[379]

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[371] *See* Porter & van der Linde, *supra* note 21, at 111 (explaining that prescription of technology standards will halt innovation).

[372] AMBEC ET AL., *supra* note 20, at 2–5.

[373] Porter & van der Linde, *supra* note 22, at 124.

[374] *Id.*; Porter & van der Linde, *supra* note 21, at 110.

[375] *See* Porter & van der Linde, *supra* note 22, at 124 (explaining that market incentives prompt companies to innovate solutions rather than rely on old technology).

[376] *Id.*

[377] Porter & van der Linde, *supra* note 21, at 111.

[378] *See infra* notes 380–421 and accompanying text.

[379] *See infra* notes 410–421 and accompanying text.

i. Pollution Tax

One type of market-based regulatory instrument that the PH recommends is a pollution tax.[380] Under a pollution tax, policymakers set a price that polluters must pay for the GhG the polluter emits.[381] Policymakers imposing a pollution tax have a choice as to the mechanics of the tax. They can impose a tax only beyond certain GhG emission levels or they can impose a tax on all GhG emissions.[382]

As explained earlier, crypto miners do not themselves directly emit GhG emissions;[383] the company from whom they receive energy does.[384] A pollution tax for crypto miners, however, could still work: miners could pay the tax based on the amount of fossil fuels they use and, therefore, the amount of GhGs the energy provider emits on the miners' behalf. The method of tracking the exact mix of fossil fuels and renewable energies used by individual crypto miners is proposed later in this Part.[385] Tracking would provide the data necessary to impose a tax that distinguishes between the types of energy used to mine crypto.

Pollution taxes provide polluters with considerable flexibility to innovate to meet the regulatory standards[386] because they are neutral about how the polluter reduces their GhG emissions.[387] For example, to avoid or reduce their taxes, crypto mining companies could use more renewable energies, switch to mining less energy-intensive cryptos (like PoS), or develop a process that reduces the amount of energy needed to mine PoW cryptos.

In addition to providing flexibility, such a tax will likely encourage miners to make product and process changes to eliminate or reduce their GhG emissions. More specifically, a pollution tax would force miners to view each ton of GhG that they emit as a financial burden, thus internalizing the cost they

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[380] Porter & van der Linde, *supra* note 22, at 124.

[381] *See* AMBEC ET AL., *supra* note 20, at 11 (discussing the argument that pollution taxes are a better regulatory tool than permit trading); Porter & van der Linde, *supra* note 21, at 111 (encouraging the use of pollution taxes as a regulatory tool).

[382] *See* AMBEC ET AL., *supra* note 20, at 11 (providing a discussion and explanation of pollution taxes); Porter & van der Linde, *supra* note 21, at 111 (same).

[383] *See supra* note 122 and accompanying text.

[384] Story, *supra* note 7, at 44–45.

[385] *See generally* Robert Walton, *Sen. Warren Leads Lawmakers Calling for DOE, EPA to Track 'Disturbing' Bitcoin, Ethereum Energy Use*, UTIL. DIVE (July 19, 2022), https://www.utilitydive.com/news/warren-lawmakers-doe-epa-bitcoin-energy-use-emissions/627554/ [https://perma.cc/KVP6-V5WU] (proposing legislation to track sources of energy from crypto miners).

[386] ORG. FOR ECON. CO-OPERATION & DEV., ENVIRONMENTAL TAXATION: A GUIDE FOR POLICY MAKERS 1 (2011), https://www.oecd.org/env/tools-evaluation/48164926.pdf [https://perma.cc/G35Z-8NL4].

[387] *Id.*

currently impose on society.[388] Subsequently, miners will be encouraged to invest in R&D to discover solutions to reduce their GhG emissions and, thus, their financial burden.[389]

If designed correctly, crypto miners will respond to the pollution tax in a manner mirroring Dow Chemical's response to environmental regulations in the 1980s.[390] Dow Chemical redesigned its production process to reduce its reliance on harmful pollutants while still producing the same product.[391] This change kept Dow in compliance with the relevant environmental regulations and saved the company $2.4 million per year.[392]

Further, such a tax will encourage competition among miners to eliminate or reduce their individual tax burdens. By reducing the amount due to the pollution tax, a miner would gain an advantage over its competitors because it could use the money saved to invest in other areas of its business. For these reasons, U.S. policymakers should strongly consider implementing a pollution tax on miners.

As stated earlier, policymakers imposing a pollution tax can choose to tax only beyond certain GhG emission levels or on all GhG emissions.[393] Policymakers should strongly consider taxing all GhG emissions from crypto miners, as doing so would align with the PH principles. Specifically, one of the goals of the PH is for regulations to "foster continuous improvement."[394] If a miner has to pay a tax for all of its emissions, it will have a constant incentive to innovate, reduce its emissions and, ultimately, reduce its taxes.[395]

Conversely, per the PH, "setting [GhG] emission levels, while preferable to choosing a particular technology, still fails to provide incentives for continued and ongoing innovation and will tend to freeze a status quo until new [emissions levels] appear."[396] Setting emissions levels does not incentivize ongoing innovation because once a miner reduces its GhG emissions under that threshold, the pollution tax no longer incentivizes the miner to reduce its tax bill.[397] Accordingly, policymakers should at least consider taxing all GhG emissions from crypto miners.[398] To be clear, setting certain emissions levels

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[388] Story, *supra* note 7, at 44–45.

[389] *Id.*

[390] *See* Porter & van der Linde, *supra* note 22, at 125–26 (showing that Dow Chemical saved millions of dollars annually after being forced to innovate by regulation).

[391] *Id.*

[392] *Id.*

[393] *See* AMBEC ET AL., *supra* note 20, at 11 (discussing the benefits of pollution taxes).

[394] Porter & van der Linde, *supra* note 21, at 110.

[395] *Id.* at 111–12.

[396] *Id.* at 111.

[397] *Id.*

[398] It should be noted that due to the current political climate in the United States, it is unlikely that taxing all GhG emissions from crypto miners would pass in Congress. *See* Stein & Romm, *supra*

still aligns with the PH, but taxing all emissions would fulfill the PH more completely.[399]

To circle back to a previous example, new, strict regulations prompted 3M not only to reduce emissions by ninety percent, but to completely eliminate the need for polluting solvents in production.[400] Similarly, regulations that incentivize crypto miners—through a tax—to substantially, or completely, reduce their GhG emissions could help them discover a way to eliminate their need for fossil fuels. Such a tax could, for example, help push miners to engineer a way to take advantage of the many green energy tax credits available[401] and start their own wind or solar panel farms that power their operations.[402]

To understand what a successful pollution tax based on PH principles would look like under the proposed regulatory program, it is helpful to compare the Biden Administration's proposed DAME Tax. As mentioned, the Biden Administration proposed the DAME Tax to curb crypto mining pollution.[403] If enacted, the DAME Tax would require all crypto miners to pay a thirty percent tax on the cost of the electricity, regardless of the type of energy powering the electricity.[404] The DAME Tax is not truly a pollution tax because it taxes all forms of electricity consumption by miners, not just the ones that emit GhGs.[405]

The DAME Tax is largely out of step with the PH, but still aligns with the PH's principles in some respects. First, the DAME Tax does not mandate that miners use a specific technology.[406] Also, given its hefty price tag, the tax would likely encourage some miners to make some product and process changes to reduce energy usage.

The DAME Tax does not, however, incentivize flexible solutions.[407] Specifically, the DAME Tax would only incentivize miners to reduce their energy

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note 174 (discussing Republicans' unwillingness to increase taxes on crypto miners). However, given the benefits enumerated here, Congress should be aware of this option and at least consider it.

[399] *See* Porter & van der Linde, *supra* note 21, at 110 (explaining that the main goal of regulations should be outcomes rather than the means of achieving them).

[400] *Id.* at 103.

[401] *See generally How Tax Credits Can Be Used to Capitalize on the Green Transition*, THOMSON REUTERS (Apr. 24, 2023), https://www.thomsonreuters.com/en-us/posts/esg/tax-credits-green-transition/ [https://perma.cc/KD9H-FJ25] (explaining the advantages of a tax credit investment system that allow businesses to deduct from their taxes).

[402] *See, e.g.*, Aoyon Ashraf, *Solar-Powered Bitcoin Miner Starts Operations Despite Difficult Market*, COINDESK, https://www.coindesk.com/business/2022/06/23/new-solar-powered-bitcoin-miner-launches-operations-despite-difficult-market/ [https://perma.cc/8YHH-L5JM] (May 11, 2023) (highlighting the work of Aspen Creek Digital to utilize solar power to run its mining operations).

[403] *The DAME Tax: Making Cryptominers Pay for Costs They Impose on Others*, *supra* note 13.

[404] *Id.*

[405] *See id.* (imposing a tax indiscriminately on energy usage, rather than energy source).

[406] *See id.* (omitting any mention of technology-specific regulation and instead focusing on energy usage alone).

[407] *See id.* (failing to implement the tax in a manner consistent with the PH's flexibility standard).

usage. It does not encourage miners to make other environmentally friendly changes, most notably increasing their use of renewable energies, as a miner who converts to using all renewable energies would still have to pay a thirty percent tax.[408]

Although the proposed pollution tax is not perfect, it would provide more flexibility than the DAME Tax. As the PH explains, incentivizing flexible approaches to meet environmental standards is critical to reducing environmental harm and spurring innovation and competition.[409]

The Biden Administration missed an opportunity by not proposing a true pollution tax more in line with the PH's principles. Doing so may have been more politically palatable and, if enacted, provided more environmental protection and more health benefits, spurred innovation, and increased competition within the crypto mining industry.

ii. Cap-and-Trade Program

Under a cap-and-trade program, each company is given a permit that authorizes them to emit a specific quantity of pollution.[410] If a company's pollution exceeds that threshold amount, it has two options.[411] It can pay a fine for the quantity in excess of the threshold amount.[412] Alternatively, it can purchase permits from other companies—whose emissions are lower than the permitted amount—on the free market.[413]

A cap-and-trade program provides flexibility for individual companies to set their own compliance path as it gives companies total freedom to decide how to comply with the regulations.[414] This freedom incentivizes innovation because there is no set path to regulatory compliance.[415] Such a program also incentivizes innovation because an innovative company could reap financial

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[408] *See* Ben Adler, *Biden Proposes 30% Climate Change Tax on Cryptocurrency Mining*, YAHOO! NEWS, https://news.yahoo.com/biden-proposes-30-climate-change-tax-on-cryptocurrency-mining-120033242.html [https://perma.cc/L2RE-MS4V] (May 2, 2023) (pointing out that the DAME Tax would penalize crypto miners for using renewable energies).

[409] *See* Faure, *supra* note 255, at 307 (quoting Bansal & Gangopadhyay, *supra* note 365, at 345–46, 358–59) (explaining that an agency's commitment to a particular level of regulation will in turn lead to effective technology development by regulated firms); Porter & van der Linde, *supra* note 21, at 110–11 (explaining that a lack of a technology standard leads to increased investments in R&D).

[410] Luca Taschini, Simon Dietz & Naomi Hicks, *Which Is Better: Carbon Tax or Cap-and-Trade?*, LONDON SCH. OF ECON. & POL. SCI. (Mar. 21, 2014), https://www.lse.ac.uk/granthaminstitute/explainers/which-is-better-carbon-tax-or-cap-and-trade/ [https://perma.cc/QS4G-RFA5].

[411] *Id.*

[412] *Id.*

[413] *Id.*

[414] AMBEC ET AL., *supra* note 20, at 2.

[415] ORG. FOR ECON. CO-OPERATION & DEV., *supra* note 386, at 1.

rewards—both by saving regulatory costs and increasing revenues.[416] For example, if a mining company reduces its emissions to 50% of the permitted threshold, it not only avoids fines it would otherwise have to pay, but it can also then sell its 50% capacity permit on the free market to another miner.[417] Such a program also would encourage a miner exceeding the limit to innovate and invest resources to develop a way to lower its emissions because, otherwise, it would have to pay each year to acquire another miner's permitting capacity.[418]

Both a cap-and-trade program and a pollution tax will likely improve the environment and spur innovation and competition. For crypto mining, however, a pollution tax is preferable. Regulatory certainty is even more important for a nascent industry like crypto.[419] The industry is still grappling with what it is at its core, and it has generally gone unregulated since the first crypto was created. A pollution tax provides more certainty in that "the price of emitting a unit of pollution is set"[420] and miners would know the exact cost of each ton of GhG they emit. Conversely, cap-and-trade programs create uncertainty about the cost of purchasing an emissions permit, as their cost fluctuates based on changes in the market.[421]

2. Encourage Product and Process Changes That Reduce Pollution Rather Than Focusing on Secondary Treatment

The PH also suggests that policymakers strive to "encourage product and process changes to better utilize resources and avoid pollution early."[422] Product and process changes for crypto miners would include solutions like using renewable energy and reconfiguring the production process to use less energy.

Product and process changes are better both for the environment and the company making the changes. On the one hand, they reduce or eliminate the company's environmental harm at its core.[423] At the same time, making product and process changes is typically financially beneficial for the polluting

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[416] *Id.*

[417] *See* Brad Plumer & Nadja Popovich, *These Countries Have Prices on Carbon. Are They Working?*, N.Y. TIMES (Apr. 2, 2019), https://www.nytimes.com/interactive/2019/04/02/climate/pricing-carbon-emissions.html [https://perma.cc/9WL4-GVS4] (giving an overview of global carbon pricing initiatives).

[418] *How Cap and Trade Works*, ENV'T DEF. FUND (Jan. 27, 2017), https://www.edf.org/climate/how-cap-and-trade-works [https://perma.cc/4VAB-VD66].

[419] *See supra* note 238 and accompanying text (explaining the importance of regulatory certainty in growing economies and industries).

[420] Taschini et al., *supra* note 410.

[421] *Id*.

[422] Porter & van der Linde, *supra* note 21, at 111.

[423] *Id.*

company.[424] Product and process changes often decrease a company's expenses, increase its revenue, or improve its resource productivity.[425] For example, if a miner makes a change that allows it to use less energy, that miner's expenses will decrease, its net income will increase, and ultimately, it will have a competitive advantage over other miners.

Policymakers can also encourage product and process changes by promulgating regulations that avoid the use of secondary treatment, use phase-in periods, and set realistic compliance deadlines. These latter two aspects are discussed in Part IV.C, addressing regulatory implementation.[426] As to secondary treatment, many U.S. environmental regulations allow or encourage the use of secondary treatment of pollution to satisfy their standards.[427] Secondary treatment of pollution is when pollution is treated after it has been released into the environment, rather than before, to mitigate some of its impact, and then rerouted to another part of the environment, or captured and stored.[428] An example is when GhG emissions from the burning of fossil fuels in a power-generating facility are captured, rerouted, and then either stored underground in geological formations or in storage containers.[429] This process is called carbon capture and storage (CCS).[430]

Secondary treatment generally is far less beneficial for the environment and the regulated industry, as it only reduces *some* of the environmental effects of the pollution.[431] Moreover, secondary treatment is typically more expensive in the long term for a company than making product or process changes that improve resource efficiency.[432] Further, secondary treatment does not finan-

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[424] Porter & van der Linde, *supra* note 22, at 122, 125–29.

[425] *Id.*

[426] *See infra* notes 450–516 and accompanying text.

[427] *See generally* Porter & van der Linde, *supra* note 22 (stating that many companies opt for "end-of-pipe" solutions as a cheap and inefficient compliance measure); Porter & van der Linde, *supra* note 21 (arguing that technology standards cause companies to implement inefficient secondary solutions rather than developing a new technology).

[428] *See, e.g.*, EPA OFF. OF WATER, NO. 833-F-98-002, HOW WASTEWATER TREATMENT WORKS . . . THE BASICS 2–4 (1998) (explaining secondary treatment of pollution through the example of wastewater treatment).

[429] *What Is Carbon Capture and Storage?*, NAT'L GRID [hereinafter *Nat'l Grid CCS Explanation*], https://www.nationalgrid.com/stories/energy-explained/what-is-ccs-how-does-it-work [https://perma.cc/DA9F-T5Q5] (Feb. 28, 2023); *What Is Carbon Capture and Storage?*, CLIMATE COUNCIL (Aug. 2, 2023) [hereinafter *Climate Council CCS Explanation*], https://www.climatecouncil.org.au/resources/what-is-carbon-capture-and-storage/ [https://perma.cc/QJ79-ZKAS].

[430] *Nat'l Grid CCS Explanation*, *supra* note 429; *Climate Council CCS Explanation*, *supra* note 429.

[431] *See* EPA OFF. OF WATER, *supra* note 428, at 2 (stating that secondary treatment only "removes about 85 percent" of the harmful pollutants).

[432] *See generally* Porter & van der Linde, *supra* note 22 (discussing the issues with the use of secondary treatment solutions); Porter & van der Linde, *supra* note 21 (arguing that technology standards cause do not force efficient solutions or technological innovation).

cially benefit the polluting company in the long run as it is often very expensive and otherwise does not produce revenue gains for the company.[433] Thus, the PH discourages policymakers from promulgating regulations that encourage secondary treatment.[434]

Although crypto miners do not directly emit GhGs, they may argue that they should be allowed to satisfy environmental regulations if their energy provider uses a secondary treatment method like CCS. Miners are even more likely to make this argument given that many crypto mining companies are the sole or primary customer for many fossil fuel plants and could effectively require plants to use such methods.[435] Policymakers can guard against this by ensuring that their regulations do not allow secondary treatment to satisfy their standards. For example, if a pollution tax is set to track and tax the tonnage of GhGs a miner causes its energy provider to *actually* emit, this could encourage secondary treatment. More specifically, if a miner's energy provider uses fossil fuels to power its energy and also uses CCS as secondary treatment of its GhG emissions, that miner's GhG emissions would likely appear lower than the actual amount of fossil fuels the miner consumed. Therefore, policymakers should consider tracking the amount of fossil fuel the miner consumed irrespective of emissions. That way, the miner is still financially incentivized to reduce the pollution at its source.

Policymakers should also act to avoid encouraging crypto miners to use CCS to satisfy their regulatory requirements. CCS has been studied extensively, and there are serious doubts as to whether CCS actually benefits the environment.[436] Further, even if it is environmentally beneficial, questions remain as to whether CCS is economically viable for companies to implement on a large scale.[437]

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[433] *See* Porter & van der Linde, *supra* note 22, at 122, 124, 128–29, 131 (reiterating the reality that pollution represents inefficiencies, and providing examples to support the claim).

[434] *See id.* (illustrating the argument that high levels of pollution merely show high levels of resource inefficiency); Porter & van der Linde, *supra* note 21, at 107 (stating that there are many "manifestations of inefficiency like emissions and discharges").

[435] *See* Cho, *supra* note 4 (discussing how a crypto company bargained with a failing plant to become its sole customer).

[436] *See* Taylor Kubota, *Stanford Study Casts Doubt on Carbon Capture*, STAN. NEWS (Oct. 25, 2019), https://news.stanford.edu/2019/10/25/study-casts-doubt-carbon-capture/ [https://perma.cc/4YAE-45P2] (explaining that carbon capture is prohibitively expensive, has enormous social costs, and generally trades carbon pollution for other kinds of pollution); Sam Meredith, *Carbon Capture Is Expected to Play a Pivotal Role in the Race to Net Zero Emissions. But Not Everyone Agrees*, CNBC, https://www.cnbc.com/2021/07/20/climate-crisis-and-carbon-capture-why-some-are-worried-about-its-role.html [https://perma.cc/8T9W-M7HT] (July 23, 2021) (arguing that carbon capture is too expensive and distracts from the crucial goal of switching to green energy).

[437] Andrew Moseman, *How Efficient Is Carbon Capture and Storage?*, CLIMATE PORTAL (Feb. 23, 2021), https://climate.mit.edu/ask-mit/how-efficient-carbon-capture-and-storage [https://perma.cc/5KLA-Z9ZJ].

It should also be noted that if the energy consumption of crypto mining is reduced through increased computing efficiency, this could have significant benefits in other industries. Specifically, the innovative technology could be used by any industry that depends heavily on computing and computing power, such as the technology, big data, and artificial intelligence sectors.

3. Fund Pilot Projects That Seed and Spread Environmental Innovations

Regulations should also focus on encouraging industries to reduce environmental harms through innovation.[438] Funding pilot projects is one method the PH recommends "to stimulate and seed innovative new technologies."[439] The United States government has a strong track record of successfully funding such projects.[440] In 1992, the EPA funded researchers in academia and the private sector "to develop and demonstrate technologies for super-efficient refrigerators."[441] The research successfully created the technology, which, in turn, demonstrated to the industry that it could achieve similar results.[442]

Further, these types of projects can raise consumer awareness that more environmentally friendly products exist and are achievable.[443] This increased awareness allows those consumers to demand greener products, which subsequently encourages companies to begin producing them.[444]

Policymakers could also directly fund R&D exploring greener ways to mine for crypto. For example, they could fund research in universities and crypto trade associations on ways to reconfigure crypto mining to use less energy and to make renewable energies more readily available to miners. Likewise, policymakers could launch competitions with cash prizes. Although this may seem unorthodox, "[t]oday, incentivized, open competition has become a standard tool in every Federal agency's toolbox for delivering more cost-effective and efficient services and advancing agencies' core missions."[445] U.S.

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[438] Porter & van der Linde, *supra* note 21, at 112.

[439] *Id.*

[440] *Id.*

[441] *Id.*

[442] *Id.* at 111–12.

[443] *See* Frey, *supra* note 307 (discussing how companies should capture the explosion of customer demand for sustainable products).

[444] *See id.* (reporting that over 60% of customers report a willingness to pay more for sustainable goods).

[445] Off. of Soc. Innovation & Civic Participation, *Prizes and Challenges*, THE WHITE HOUSE: PRESIDENT BARACK OBAMA, https://obamawhitehouse.archives.gov/administration/eop/sicp/initiatives/prizes-challenges [https://perma.cc/M3CF-3W84] (exhibiting the Obama Administration's view on the topic in 2015).

government sponsorship of such competitions has produced great results, including "an improved digital wallet user interface" and self-driving vehicles.[446]

For example, policymakers could offer $1,000,000 to anyone who is able to reduce PoW's GhG emissions to levels similar to PoS's GhG emissions. Likewise, they could offer $100,000 to anyone who develops a technology that reduces PoW's GhG emissions by 10% or more—it is easier to reduce PoW's impact by 10% at a time than it would be to reduce it all at once.

Additionally, regulators could offer cash prizes to anyone who can develop a way for miners to use more renewable energies to power their operations. Many miners have complained that renewable energies are not reliable enough for them to use, so proving that using a significant amount of green energies is possible, and financially viable, in crypto mining could entice new entrants into the crypto mining space.[447] This will be especially true if policymakers implement the suggested pollution tax on all GhG emissions, which would give miners an additional strong incentive to move away from fossil fuels and toward renewable energies.

In the TSCA example examined previously, TSCA completely banned the use of PCBs.[448] Then, Dow Silicone entered the market with an environmentally friendly solution that improved not only the environment but also Dow Silicone's revenue.[449] In the crypto context, a pollution tax on miners' GhG emissions could lead to similar results—new entrants and an improved environment. A renewable energy company could, for example, enter the mining market with an immediate competitive advantage because it would not have to pay the pollution tax. Furthermore, it would already have the knowledge, experience, and infrastructure for using and implementing renewable energies.

C. Implementation: Phase-in Periods, Reasonable Deadlines, Information Monitoring, Publication, and Stability

The final category of principles suggested by the PH are principles relating to implementing regulations.[450] The PH instructs that regulations should include phase-in periods[451] and deadlines that are realistically achievable[452] to provide the industry time to research, develop, and implement new technolo-

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[446] *About Challenge.Gov*, CHALLENGE.GOV, https://www.challenge.gov/about/ [https://perma.cc/BS7F-4DPS].

[447] *See* Ashford & Hall, *supra* note 195, at 279 (explaining that pilot projects "can stimulate new entrants to introduce *entirely new products and processes* into the market") (emphasis added).

[448] *Learn About Polychlorinated Biphenyls*, *supra* note 280.

[449] Porter & van der Linde, *supra* note 22, at 125–26.

[450] AMBEC ET AL., *supra* note 20, at 3.

[451] Porter & van der Linde, *supra* note 22, at 124.

[452] *Id.*

gy.[453] The PH also calls for regulators to gather, disseminate, and publicize pollution information for individual companies in environmental regulations.[454] Gathering and publicizing this information allows companies to compete more effectively, allows consumers to make informed decisions,[455] and should help regulators gauge the effectiveness of regulations. Finally, the PH directs that "the regulatory process should leave as little room as possible for uncertainty" by committing to keeping the rules in place for five years.[456]

Accordingly, this Section discusses all of these solutions in greater detail. Subsection 1 touches upon the importance of phase-in periods.[457] Subsection 2 stresses the need for realistic deadlines.[458] Subsection 3 discusses the importance of data collection and dissemination.[459] Finally, Subsection 4 explains the importance of regulatory certainty.[460]

1. Use Phase-in Periods

Phase-in periods are periods of time in which regulators implement "full" standards progressively, moving through a series of stages with increasingly demanding standards.[461] Phase-in periods often heighten the regulations over several years by slowly increasing the standards as the enactment date for the "full standards" draws near. The phase-in period ends once the enactment date occurs.

Phase-in periods would give miners time to research, develop, and implement innovative technologies that reduce their environmental harm.[462] If policymakers do not use phase-in periods, they run the risk of encouraging miners to hastily implement measures that have not been adequately researched.[463] Miners also may simply not achieve the necessary emissions reductions. Instead, those miners would just buy tradeable permits or pay the pollution tax—it is easier and cheaper in the short term to do so. Accordingly, policymakers should use phase-in periods that provide miners with ample time

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[453] *Id.*

[454] Porter & van der Linde, *supra* note 21, at 100.

[455] *Id.*

[456] *Id.* at 110, 113.

[457] *See infra* notes 461–469 and accompanying text.

[458] *See infra* notes 470–482 and accompanying text.

[459] *See infra* notes 483–496 and accompanying text.

[460] *See infra* notes 497–516 and accompanying text.

[461] *See* Porter & van der Linde, *supra* note 22, at 124, 129 (highlighting the importance of effective and realistic phase-in periods, as well as providing examples of failures to set such periods).

[462] *See id.* (discussing the importance of phase-in periods when a regulator is trying to force innovation).

[463] *See id.* (highlighting that such solutions are often unnecessarily expensive as well).

for implementation and clearly communicate to miners that tougher regulations will follow.

A comparison of the differing approaches to environmental regulation of the pulp and paper sector in Sweden and the United States shows how phase-in periods can spur innovation.[464] In the 1970s, the United States enacted strict environmental regulations, which lacked a properly planned phase-in period, on the sector.[465] This forced companies to "install[] proven but costly [secondary] treatment systems."[466] Predictably, U.S. pulp and paper companies did not innovate any further, as they did not have adequate time to conduct R&D.[467]

Conversely, Sweden used a longer phase-in period and allowed Swedish companies "to focus on the production process itself."[468] This resulted in new and innovative technologies that allowed companies to meet emissions standards as well as lower their costs.[469]

Given that environmental regulations for crypto miners would be the first of their kind, policymakers should strongly consider implementing a phase-in period. For example, if legislators choose to use a cap-and-trade program, policymakers could start by using a GhG emissions threshold that is 50% of the final emissions threshold, then increase it to 75% after one year, and impose the full threshold two years after the inception of the program.

2. Set Realistic Compliance Deadlines

Similarly, the PH recommends that U.S. policymakers ensure that they set compliance deadlines for their "full" environmental regulations that are realistically achievable.[470] Just like phase-in periods, compliance deadlines should provide miners with adequate time to research, develop, and implement innovative technologies that reduce their environmental harm and comply with the environmental regulations.[471] This is especially true given that miners have not had to previously comply with industry-specific environmental regulations like the ones this Article proposes.[472]

If regulators set compliance deadlines that are too short, they run the risk of encouraging miners to hastily implement measures that have not been ade-

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[464] *Id.* at 129–30.

[465] *Id.* at 129.

[466] *Id.*

[467] *See id.* (explaining that the United States' usage of secondary treatment solutions caused stagnation in the industry).

[468] *Id.*

[469] *Id.*

[470] *Id.* at 124, 129.

[471] *See id.* (exemplifying the benefits of using proper phase-in periods).

[472] *See supra* Part II (explaining the lack of crypto regulation in the United States and the hurdles that exist to implement new regulations).

quately researched and developed.[473] Even worse, miners may simply flee to other countries.[474] As stated previously, miners fleeing to another country would likely reduce the localized environmental harms caused by crypto mining, but the United States would still feel the global repercussions of the companies' environmental impact.[475]

The U.S. federal government, as well as some states, have previously set short compliance deadlines for environmental regulations.[476] For example, California imposed environmental regulations on the wood-furniture industry.[477] The compliance deadline was so short that California manufacturers were faced with either adding expensive secondary-treatment equipment or leaving the state.[478] Many producers moved their operations outside the state.[479]

As previously highlighted, in the 1990s, the United States enacted new regulations that required many manufacturers and users of solvents to reduce their solvent emissions by ninety percent.[480] Because these regulations gave companies several years before enforcing the first compliance deadline, however, the regulations maximized the opportunity for innovation.[481] This lead time gave polluters adequate time to R&D proper solutions.[482]

The PH does not specify the best length of time for a deadline. Therefore, this is where industry involvement in crafting the regulations would help policymakers. Industry could provide insight as to the amount of time that would be adequate for miners to be able to comply and, thus, help create deadlines that are actually achievable. Conversely, policymakers with little knowledge of the ins and outs of crypto mining, and who refuse to consult the experts in the industry, are less likely to implement deadlines that are realistic and adequate.

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[473] Porter & van der Linde, *supra* note 22, at 129 (holding up the American pulp-and-paper industry as an example).

[474] *See* AMBEC ET AL., *supra* note 20, at 9 (introducing the counterargument that overly strict regulation may induce flight to "pollution haven[s]").

[475] *See supra* note 81 and accompanying text (providing different explanations as to how the effects of climate change are not isolated to the location of the emissions, but affect the global climate).

[476] Porter & van der Linde, *supra* note 22, at 129.

[477] *Id.* at 124.

[478] *Id.*

[479] *Id.*

[480] Porter & van der Linde, *supra* note 21, at 103.

[481] *Id.*

[482] *See id.* (using 3M as an example, which developed innovative, greener coating products that improved their net profits).

3. Collect and Publish Information on the Energy Usage and Greenhouse Gas Emissions for Each Individual Mining Company

The PH suggests that regulators collect, disseminate, and publicize GhG energy usage information about individual companies.[483] Legislators should include a provision that directs the EPA to begin tracking this information.

Regulation that simply gathers and publishes fossil fuel usage and GhG emissions information can achieve major benefits by raising company, consumer, and public awareness.[484] As a point of comparison, the "Toxics Release Inventories . . . require more than 20,000 manufacturing plants to report their releases of some 320 toxic chemicals."[485] The results are then published every year.[486]

Research shows that the publication of this information "often leads to environmental improvement," even though the reporting regulation does not itself mandate pollution reductions.[487] It is likely that this improvement stems from the polluting company facing public scrutiny over their pollution levels and desire to show improvement.[488] For example, many public companies lost value on the first stock market trading day after the Toxics Release Inventories (TRI) report was released to the public.[489] As time went on, however, "[companies] with the largest stock price declines . . . subsequently reduced their emissions most."[490] Likewise, the companies that made the largest environmental improvements in the successive TRI reports experienced significant increases in the value of their stock.[491]

The United States government does not currently track and publish such information for crypto miners; however, some legislators have requested energy usage information from the largest miners.[492] There are also proposed bills that would require government agencies to collect and publish such information.[493] The U.S. government has previously created such programs for other industries that succeeded in curbing environmental harm.[494]

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[483] *Id.* at 100.

[484] *Id.*

[485] *Id.*

[486] *Id.*

[487] *Id.*

[488] *See* AMBEC ET AL., *supra* note 20, at 15 (using the example of the Toxic Release Inventory and stock prices to represent the public's response).

[489] *Id.*

[490] *Id.*

[491] *Id.*

[492] Press Release, *supra* note 144.

[493] *See supra* note 145 and accompanying text (illustrating the various attempts by Congress to gain more information on the subject).

[494] *E.g.*, *Basic Information About Air Emissions Monitoring*, EPA, https://www.epa.gov/air-emissions-monitoring-knowledge-base/basic-information-about-air-emissions-monitoring [https://perma.

The regulatory practice of collecting and publishing such information for crypto miners is especially likely to put pressure on miners to curb their environmental harm: over the last several years, consumers have become more environmentally conscious and do not want to support companies or products that harm the environment.[495] Thus, armed with this information, many crypto consumers will want to use only crypto coins that are environmentally friendly.[496]

Tracking this information will also help gauge whether the environmental regulations are working to reduce miners' GhG emissions and, thus, their environmental impact. Policymakers can then use these metrics of progress to decide whether regulations should be tightened.

4. Reduce Uncertainty by Garnering Broad Support for the Legislation and Regulations

The final suggestion for implementation is for legislators to reduce uncertainty for the industry by committing to regulatory stability for a discrete period of time.[497] Regulatory uncertainty is bad not only for companies, but also the environment.[498] Regulatory uncertainty "raises project revenue risk, which in turn, reduces project viability, investment, private sector interest and innovation."[499] More specifically, if there is regulatory uncertainty surrounding crypto mining, it is less likely a mining company will allocate resources for innovative solutions to those regulations.[500] This is largely due to the concern that shortly after investing large sums of money, regulations will change, rendering the resulting innovation pointless.[501] Thus, regulations clouded by uncertainty

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cc/2FNT-PWRV] (Aug. 2, 2023) (discussing stationary source emissions monitoring covered in the CAA); *National Emissions Inventory (NEI)*, EPA, https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei [https://perma.cc/A5K4-9NLE] (May 26, 2023) (representing a second air pollution monitoring program run by the EPA).

[495] Drenik, *supra* note 254.

[496] *See id.* (discussing the increasing demand for environmentally friendly and sustainable products).

[497] Porter & van der Linde, *supra* note 22, at 124.

[498] *See id.* (arguing that "root-cause solutions" will not be developed unless regulations are stable).

[499] George Atalla, Meghan Mills & Julie McQueen, *Six Ways That Governments Can Drive the Green Transition*, EY (May 13, 2022), https://www.ey.com/en_id/government-public-sector/six-ways-that-governments-can-drive-the-green-transition [https://perma.cc/GU7W-XBGC].

[500] *See supra* note 238 and accompanying text (discussing the impact of predictability on investment in various contexts).

[501] *See supra* note 238 and accompanying text (discussing the impacts of regulatory stability in theory and in the context of two developing economies).

could ward off R&D and result in a loss of environmental benefits for the nation and economic benefits for miners.[502]

The PH states that the best way to reduce uncertainty is for legislators to publicly commit to keeping the regulations in place and unchanged for five years.[503] When Congress commits to leaving standards in place for several years, it will incentivize "industry [to] lock in and tackle root-cause solutions instead of hedging against the next twist or turn in government philosophy."[504] The PH further explains such a commitment from legislators will result in an "industry [that] is motivated to innovate rather than adopt incremental solutions."[505] Additionally, if it is certain that the regulations will stay in place and unchanged for five years, industry is less likely to focus their resources on lobbying for more lenient environmental regulations.[506] It must be noted, however, any subsequent Congress can overturn legislation from a preceding Congress.[507] So, just because one Congress commits to keeping regulations unchanged for a period of time does not mean that another Congress, or even the same Congress, will not later overturn that legislation.[508]

There are two ways that the drafting Congress members can combat this risk. First, they can charge the overseeing agency to set standards that will last for five years and then will be revisited after five years.[509] Second, the drafting legislators should work with opposing members to craft legislation that also includes some of the opposition's preferred policy solutions—bipartisan legislation is less likely to face partisan attacks.[510] Doing so will make it clear to

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[502] *See* Susan Helper, Jason S. Miller & Mark Muro, *Why Undermining Fuel Efficiency Standards Would Harm the US Auto Industry*, BROOKINGS (July 2, 2018), https://www.brookings.edu/articles/why-undermining-fuel-efficiency-standards-would-harm-the-us-auto-industry/ [https://perma.cc/KL3B-8V85] (discussing regulatory uncertainty in the auto industry regarding fuel efficiency standards, and concluding that such uncertainty wards off innovation and results in the loss of local and national economic benefits).

[503] Porter & van der Linde, *supra* note 22, at 124.

[504] *Id.*

[505] Porter & van der Linde, *supra* note 21, at 113.

[506] *See id.* (stating that regulatory process is only successful when industry has a clear mandate with which it can comply and ceases to lobby for different regulations); Porter & van der Linde, *supra* note 22, at 124 (emphasizing the importance of regulatory certainty).

[507] *See* Nathan Richardson & Arthur G. Fraas, *Comparing the Clean Air Act and a Carbon Price*, 44 ENV'T L. REP. 10472, 10482–83 (2014) (discussing the threat posed to any environmental bill due to changing tides and political realignment in Congress).

[508] *Id.*

[509] *See generally* GARVEY & SHEFFNER, *supra* note 151 (summarizing the tools at Congress's disposal to influence agency action, including passing laws to alter the duties of agencies).

[510] *See, e.g.*, Craig Volden, *Bipartisanship the "Secret Sauce" for Effective Lawmaking, Despite Rising Polarization in Congress*, UVA FRANK BATTEN SCH. OF LEADERSHIP & PUB. POL'Y (May 31, 2023), https://batten.virginia.edu/bipartisanship-secret-sauce-effective-lawmaking-despite-rising-polarization-congress [https://perma.cc/E66P-STLS] (detailing the advantages bipartisan legislation holds over strictly partisan legislation).

miners that even if the next election cycle brings in a new majority, the regulations will remain unchanged. Such knowledge will encourage miners to invest in finding innovative solutions to satisfy those stable standards.[511]

Further, some of the proposed process suggestions and substantive suggestions will help to achieve this stability. For example, if policymakers replace their adversarial approach for a more cooperative one, this should help generate some marginal political support by incurring less opposition from the industry. Moreover, implementing a technologically flexible approach should also reduce opposition because policymakers will not be attempting to ban PoW mining or "kill off" the industry. This should also help generate some marginal political support.

Generally, many conservative legislators view lower threshold GhG emission standards as too strict, bad for business, and unnecessary.[512] To mollify these views, liberal legislators might need to consider raising the threshold of the GhG emission standards for when crypto miners are taxed or are required to get a tradeable permit to garner broad support. For the same reasons, they might wind up compromising on the dollar amount charged to a crypto miner for each ton of GhG it emits under the pollution tax. Although that would mean risking more environmental harm, it would satisfy the PH principle of reducing uncertainty. According to the PH, it is more important to have more lenient standards with minimal uncertainty than to have strict environmental regulations with little certainty of longevity.[513] Therefore, lowering the standards is a sacrifice that aligns with the PH's principle of reducing uncertainty and increases the likelihood of achieving the goals of increasing innovation and improving the environment.[514]

Additionally, conservative members of Congress traditionally prioritize economic benefits in legislation.[515] For this reason, the PH-based regulatory

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[511] *See* Porter & van der Linde, *supra* note 22, at 124 (discussing the perks of regulatory certainty and its effects on industrial innovation).

[512] *See, e.g.*, Shepardson, *supra* note 179 (illustrating Republican distaste for EPA regulations of any kind); Hulac, *supra* note 179 (illustrating that a Republican majority in Congress would attempt to roll back most of President Biden's climate regulations).

[513] *See* AMBEC ET AL., *supra* note 20, at 3 (stressing the need for regulatory certainty when creating environmental regulations); Porter & van der Linde, *supra* note 22, at 124 (same); Porter & van der Linde, *supra* note 21, at 113 (same).

[514] *See* AMBEC ET AL., *supra* note 20, at 3 (expressing that regulatory certainty when creating environmental regulations is essential for their success); Porter & van der Linde, *supra* note 22, at 124 (same); Porter & van der Linde, *supra* note 21, at 113 (same).

[515] *See* Alec Tyson, *On Climate Change, Republicans Are Open to Some Policy Approaches, Even as They Assign the Issue Low Priority*, PEW RSCH. CTR. (July 23, 2021), https://www.pewresearch.org/short-reads/2021/07/23/on-climate-change-republicans-are-open-to-some-policy-approaches-even-as-they-assign-the-issue-low-priority/ [https://perma.cc/3FNU-F4P3] (stating "Republicans place economic considerations at the top of the list when asked about the factors they view as important in proposals to deal with climate change").

program proposed in this Article will likely appeal more to these legislators than the idea of banning PoW mining or the punitive DAME Tax. Specifically, banning PoW mining will mean losing all Bitcoin mining operations and the DAME Tax will not stimulate nearly as much innovation and competition as the proposed program.

Finally, the PH also explains that if the standards and phase-in periods are set early on, this also helps "[m]ake the regulatory process more stable and predictable."[516] Therefore, policymakers should try to ensure that both of these aspects are set early in the regulatory process. This is likely especially important given that these regulations are the first of their kind for the crypto mining industry. There will likely be a longer adjustment period as miners adjust to having to comply with environmental regulations for the first time.

CONCLUSION

Crypto mining's exorbitant use of energy causes significant environmental harm. Congress and the White House are interested in curbing this environmental harm, but concerns about regulatory impact on competition and innovation are an obstacle.

This Article proposes that the principles of the Porter Hypothesis (PH) show a way to resolve this dilemma. Applying the principles of the PH calls for a regulatory process that is informed, consultative, and cooperative.

As to substance, the principles of the PH point toward regulations that use a market incentive—such as a pollution tax—that provide miners flexibility in meeting the standards and encourage product and process changes that get to the root of miners' pollution. These regulations should not mandate that miners use a specific technology, nor encourage the use of secondary treatment. Further, the government should fund pilot projects to drive innovations in crypto mining. Finally, regarding implementation, the regulations should use phase-in periods and set realistic deadlines. Regulators should collect and disseminate information on the energy usage and GhG emissions for each individual mining company to encourage competition and track effectiveness. Legislators should also commit to regulatory stability, so the industry has time to adjust and innovate methods to ensure sustainable compliance.

This program of regulation would not only reduce crypto mining's environmental harms but would also spur innovation and competition within the industry. This, in turn, would garner more political support for enacting the regulatory program.

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[516] Porter & van der Linde, *supra* note 22, at 124.

If the proposed regulatory program and mechanisms are implemented, United States crypto miners will emerge incentivized not only to curb their degradation of the environment, but also to innovate and compete. The benefits of this reform will transcend the industry and improve the environment, the climate, and public health. Using the PH principles to create environmental regulations for crypto mining could even be a test case for using the PH to inform other environmental regulations.