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Bitcoin and Economic Incentives for Renewable Energy

# 1. Recap and Introduction

As discussed in much greater detail in the CP, Bitcoin's recent growth–especially with respect to the institutional market–is not one of the most elaborate Ponzi schemes in financial history, but rather a symptom of the broken financial system[1] which results in the global need for a superior store of value. Bitcoin has achieved a level of adoption such that it can now fulfill many of its long-standing promises without the looming uncertainty that its value could collapse to nothing. The fruits of many a Hodler's[2] labor may now be realized: an apolitical decentralized financial system; uncompromising security, trust and persistence in the face of global crises; Digital Gold, a "Shining city in Cyberspace" so to speak. Be that as it may, the approach of hyperbitcoinization[3] makes it all the more urgent that we address the prevailing climate framework, for if our legislative and mental framework fail to transform, renewable energy itself may be in danger–let alone a surge in emissions due to irresponsible mining. America and The World need to stop fighting against an inevitable change, but instead harness it to build a better future.

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[1] For further reading, I would highly recommend Layered Money by Nik Bhatia
[2] HODL (Hold On For Dear Life). Moniker for people who hold Bitcoin and never sell.
[3] The point where Bitcoin becomes the default system of valuation like how assets are "worth their weight in gold". Buildings, cars etc. will be measured in how much Bitcoin they are worth.

Specifically in relation to the contents of this paper, the solution I will be discussing in greater detail and am personally a proponent of is the possibility of using Bitcoin mining to subsidize renewable energy. This initiative could potentially expand current renewable energy projects and give a more effective economic incentive than constant tax breaks and subsidies that the U.S Government has been giving for the past 20 years. There will be discussion on the current regulatory framework that could facilitate or hamper these changes; however, there will be less discussion and speculation about what new laws or actions need to be instituted. I intend for this paper to be a more broad view of the solution space while advocating for the integration of Bitcoin mining and renewable energy. A detailed plan to achieve this integration, albeit being an interesting academic endeavor, is not the paper I intend to write. I will also not be talking about the possibility of renewable energy companies using Bitcoin as capital, ie. the company owning and using Bitcoin as their primary asset. Alternative solutions such as transitioning Bitcoin to Proof of Stake (PoS) or implementing taxes based on energy use will also be discussed. Each section will detail what they propose with an emphasis on their practical impossibility and limitations.

## 2. General Obstacles Towards Success

### 2a. Public Opinion

The largest obstacle towards achieving anything productive in the Bitcoin space, let alone any product or company related to cryptocurrency as a whole, is public perception and sentiment. According to a Pew research study conducted in 2024, “Roughly six-in-ten Americans (63%) say they have little to no confidence that current ways to invest in, trade or use cryptocurrencies are

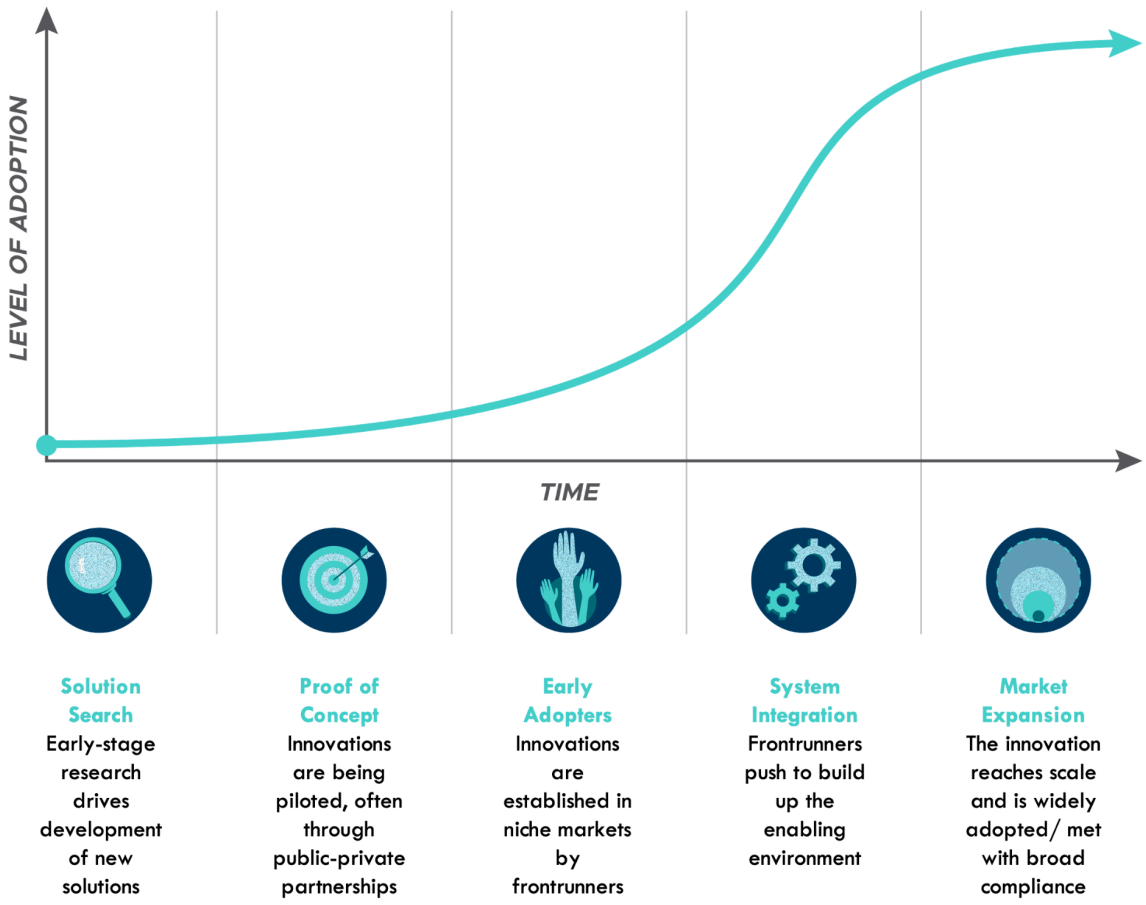
reliable and safe," (Faverio et al.). The overall trends found in the study are also consistent with the results from the three previous years' study. This is especially true after the collapse of FTX, one of the most prominent and infamous crypto scandals in recent history. As a result, 40% of Americans associated crypto with fraud, (CoinCover). Though the scandals of FTX and other crypto brokerages such as Celsius and the rise and dramatic fall of NFTs have little or nothing to do with the principles of Bitcoin, Bitcoin still takes the fall as it is the de facto representative of all crypto currencies.

That being said, overwhelmingly positive sentiment boarding on delusional fervor is also not the ideal scenario. This is especially true at the height of a bull market[4] when crypto is being pushed as a "get rich quick scheme". Everyone's aunts, uncles, cousins and neighbor's daughter's brother-in-law suddenly want to get into this "crypto thing". These unrealistic expectations set many unwitting and uninformed people into financial trouble. According to the previously mentioned Pew research study, 38% of people's portfolios did worse than expected. The inherent volatility of even Bitcoin where drawdowns historically reached 70% and explosive growth just as or even higher is something that many who were taught to simply invest in a 60/40 portfolio[5] or invest purely in the S&P 500 is simply a phenomenon which they were not taught to handle appropriately. Ironically, Bitcoin is considered stable and "slow" in the crypto community so it's not a stretch to have people who would be happy with a 10% annual return be shocked when a coin goes up 200% in a single day then back down to 50% its original value the next. Overall, the system was a lottery–just choose any coin at the right time 10x your gains– but as the ecosystem becomes more mature and stable over time, the mindset of chasing gains will not be beneficial for the general public as well as the crypto space.

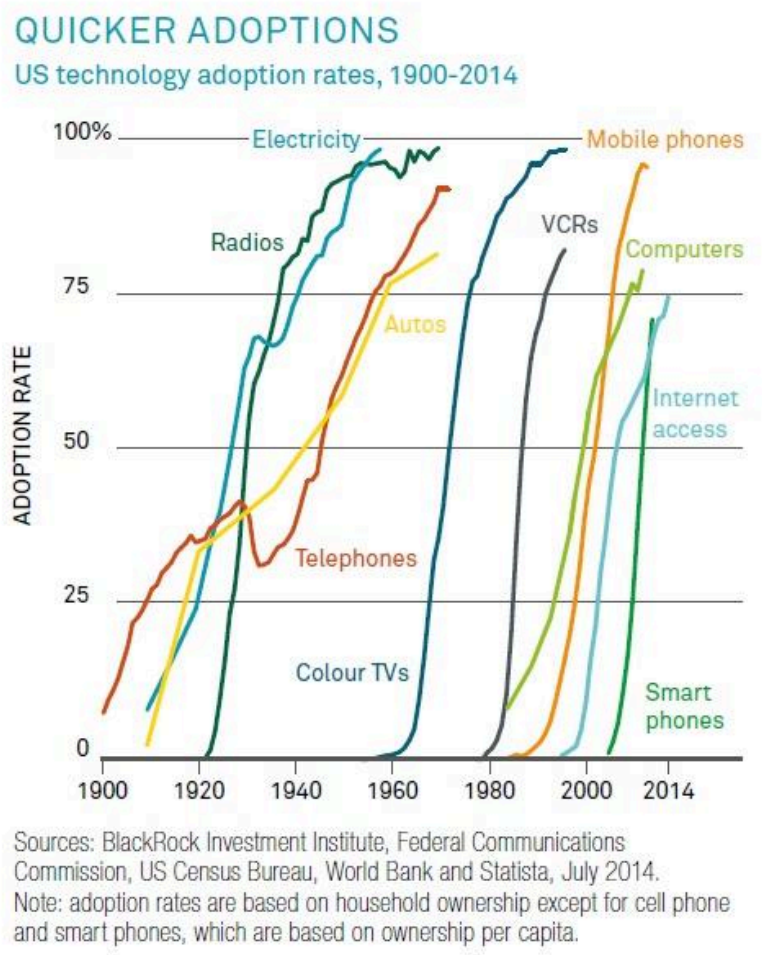
[4] Market characterized by rising prices. Opposite is a "bear market", characterized by lowering prices

[5] Traditional portfolio where 60% are in stocks and 40% are in bonds.

Cryptocurrency, especially given the myriad types and potential use cases, is fundamentally harder to communicate the importance of in a realistic sense to a lay person than a technology like ChatGPT and others. Where once ChatGPT was a novelty that one can simply "try out" in isolation, cryptocurrencies as a whole are highly dependent on the network of people that use it. In other words, if a cryptocurrency is used by little to no people despite being a good idea in theory, it is much more difficult to convince others of its value. As a result, adoption follows an "S-curve" (see figure below) which starts off slow, quickening in the middle then leveling off in the end.

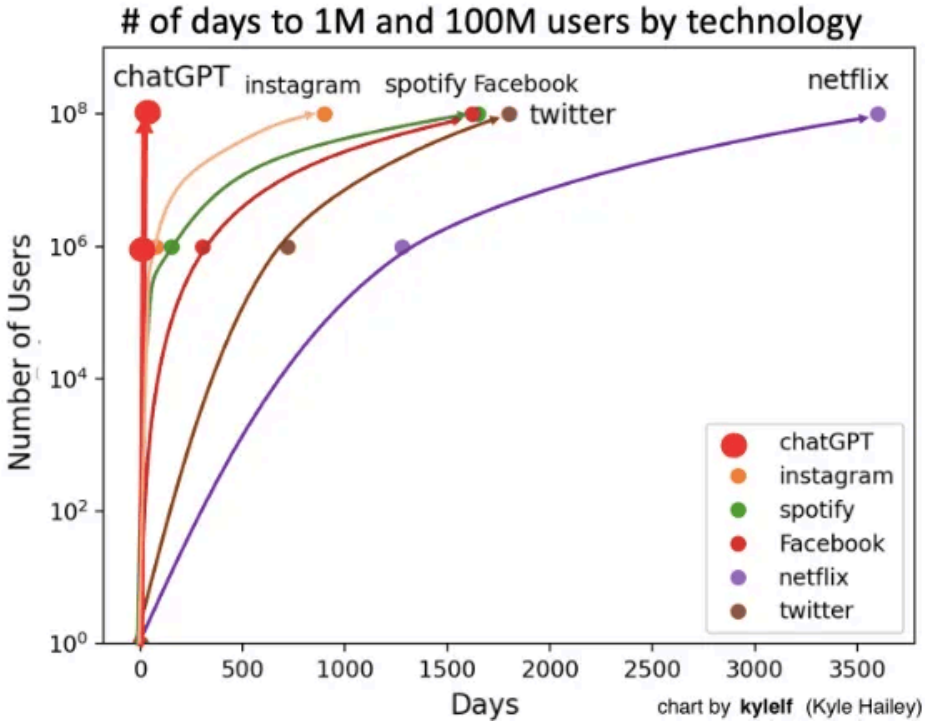


For those who need some mathematical/statistical justification, this curve is another way of framing a “normal distribution”. The specifics, however, are far beyond the course of this discussion as are the use of other models such as a Gompertz curve. Though the exact mechanisms and way of modeling is a topic for another debate, the empirical effects these models seek to describe are real.




From the chart above, we can see that different revolutionary technologies have their adoption rate start out slow. Suddenly there is a tipping point where the vast majority of the population start using the technology. Another major thing to note is that new technologies in general have “steeper” tipping points than those of older technologies. That is to say, the effects of new

technologies on society will be so sudden that reactionary moves will be impossible for corporations. An anecdotal example of this would be the rise of ChatGPT and other generative AI tools like it. The chart below largely speaks for itself. Change will happen instantly.




In summary, the issue of public opinion is extremely important. Currently, it may be difficult to garner public support for any initiative involving cryptocurrency; nevertheless, we must be properly prepared for the moment when it spontaneously becomes ubiquitous in society. We simply cannot afford to mishandle this opportunity for growth. In doing so, it can leave lasting consequences on not only the environment by irresponsible Bitcoin mining using fossil fuels but for the statute of American dominance. We must get the ball rolling in the correct direction before it's too late.

## 2b. Crypto Legislature

Crypto as of now is akin to the wild west of yore. There were little to no laws; those that did exist were not enforced or properly interpreted. Instead the prevailing law was that of the land: only the smartest or the strongest shall survive. If you get scammed it's your fault and yours alone. This picture is not attractive to the general public, especially to investors from traditional finance institutions, but it is possible to change this narrative. As there are no Billy the Kids prowling around Phoenix, Arizona; so too could there be no more explicit rug pullers given the correct intervention. Powerful outlaws become sanctioned linchpins in the system that holds the economy up today. Notwithstanding that there will be inevitable pushback from those who once enjoyed absolute freedom, it is a necessary step held by much of the community if crypto wishes to evolve into a true economic asset. That being said, laws and regulations must not only block rampant abuse but above all inspire and promote innovation. Increased protections for investors make it more attractive to invest into the space as well as less money leaving the space permanently, encouraging reinvestment. The current laws and regulations achieve the opposite of this ideal.


(Illustration by the author, generated using DALL·E, OpenAI)

The current laws which affect Bitcoin and cryptocurrencies are best described as patchwork. Currently, there are no agreed upon regulations with respect to cryptocurrency. In their place are state and federal agencies–each individual agency has a conflicting interpretation to how Bitcoin and cryptocurrency should be legally classified. The main players on the federal level are the Securities and Exchange Commission (SEC), Commodity Futures Trading Commission (CFTC) and the Internal Revenue Service (IRS). Other federal agencies to note are the U.S. Department of Justice (DOJ), Federal Deposit Insurance Company (FDIC) and the US Department of the Treasury's Financial Crimes Enforcement Unit (FinCEN). In addition to these federal agencies, because of the lack of comprehensive regulation, most of every state must apply its own laws in addition to any state specific financial laws (Sneha Solanki). From this expansive list of agencies, it is clear even without direct examples that the regulatory landscape is a mess and will likely continue to be one as cryptocurrency is a complex and novel concept. Striking the balance between a comprehensive regulatory framework while simultaneously not harming markets and consumers will most definitely be the hallmark challenge. For this overview, I will largely be focusing on the key existing federal legislation enforced by the SEC and CFTC with some mention of other agencies as they relate to the overall topic. I will also be focusing on legislation proposed that is anti/pro crypto. This will most definitely not be a comprehensive list on all there is about legislation as it is far beyond the scope of the AP. What I do intend to accomplish is to give a brief insight into the complicated landscape–which I do not fully understand nor do I believe anyone truly does–that is ailing cryptocurrency.

One of the key pieces of legislation that hampers cryptocurrency development in the United States is the Securities Act of 1933 and the accompanying Howey Test which determines whether an asset is a security. "All four conditions of the Howey test must be met for an asset to

be a security: (1) an investment of money; (2) in a common enterprise; (3) with a reasonable expectation of profit; and (4) through the entrepreneurial or managerial efforts of others," (Birry et al.). Many crypto proponents disagree with how this is applied broadly to many currencies. Purely decentralized currencies such as Bitcoin do not fit requirement 2, that is being in a "common enterprise" ie. one company and recently Ethereum was also lifted from this restriction. However the vast majority of cryptocurrencies are considered securities by the SEC (Gratton). There are many reasons why this should not be the case for some coins. Bitcoin is purely decentralized meaning there is no common enterprise. Some coins are not fully decentralized; however, they should be exempt because they are considered "utility" coins. A utility coin is a token whose main purpose is to facilitate a task such as securing a transaction. There is ongoing debate in legal systems regarding which coins are securities such as Ripple's lawsuit against the SEC ending in Ripple's favor that their token, XRP, is not a security. "This decision was part of a broader challenge to the long-standing "Chevron deference," which typically grants federal agencies significant leeway in their interpretations…" (Gratton).

In addition the SEC under Gary Gensler has been particularly anti crypto by implementing "regulation by enforcement". The SEC does not push for new legislation that clarifies what can and cannot be done with cryptocurrencies given its unique capabilities: it would rather pursue litigation for an interpretation of the hazy laws which is noncompliant with its agenda. Hester Peirce commissioner of the SEC comments on this: "The decision by the previous Commission to shift this function to the Division of Enforcement by engaging in a large-scale regulation-by-enforcement initiative harmed the American public, adversely affected the industry, and impeded the ability of the Commission's skilled and dedicated professional staff to use their expertise as it was intended to be used," (SEC).

Though Bitcoin is considered by the SEC as a commodity, not a security, it being a cryptocurrency makes it dependent on the current regulatory landscape by proxy. In addition SEC rulings on Bitcoin being a commodity only apply to the Bitcoin currency itself and not its derivatives associated with it. An unfavorable SEC administration could stop Bitcoin progress in the United States causing all new innovations to move overseas and mining along with it to countries with less regulation overall, including those that are climate related.

In addition to current regulatory laws, passing laws that more accurately clarify crypto in the legislature has been an ongoing challenge with opposition largely from the Democratic party. An example of this would be the Financial Innovation and Technology for the 21st Century Act (FIT21) which is the beginnings for an outline for a possible method to determine which agencies a given cryptocurrency falls under. The current proposition is shared jurisdiction under the SEC and CFTC if the token is "centralized" enough and only under the CFTC is the token sufficiently decentralized. Though not without its weaknesses, it provides the groundwork for a more accurate regulatory framework for cryptocurrencies by directly addressing the key aspect of decentralization. Instead of making progress with further deliberation and amendments, the bill has stalled in the Senate after being passed in the House of Representatives since May 2024, (Kielar and Guha). More groundwork needs to be done to better codify the ins and outs of crypto into law. There is some progress however with the admission of the GENIUS act to the Senate floor (United States) which seeks to define and regulate stablecoins–coins that represent 1 unit of a physical currency.

There are also anti-crypto regulations that have been proposed in the past which would make it harder to achieve any objectives in space. The most relevant to this discussion is the Digital Asset Anti-Money Laundering Act of 2022. The long and short of it is that the law would

make non direct participants of the blockchain network–wallet providers, validators and most importantly miners–subject under regulations which require them to collect data on customers without their knowledge and consent. Not only is this a breach of privacy but also unfeasible given a misunderstanding of what blockchain technology does and what data a miner has access to, (L0La L33Tz). This could increase the compliance costs that miners and other essential bodies have to face, causing them to move away from the U.S to unregulated countries where action is simply not possible.

Again to reiterate, if miners move away to less regulated places, they will go to places that predominantly use fossil fuels, (Drage). It's a correlation not causation. It is not out of malice they use fossil fuels but out of necessity to be profitable with tight margins given the current volatility of Bitcoin as an asset, (Solimano).

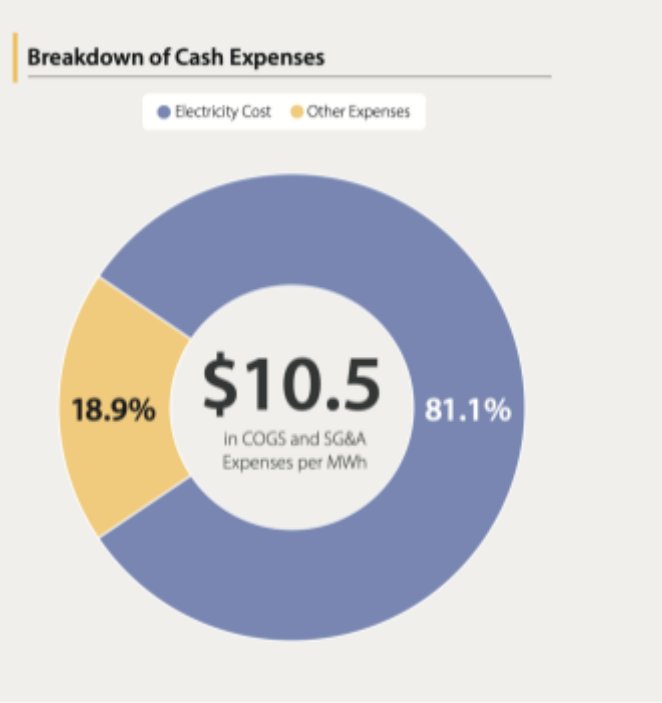



Figure from the Cambridge Mining Study. Shows the proportion of costs directly traced back to electricity.

# 3. Flawed Bitcoin Emission Reductions

## 3a. Energy Tax

Taxing the energy usage of Bitcoin miners has been the goto for governments around the world to curtail Bitcoin mining. Sweden in 2023 raised taxes on energy usage by crypto miners by 6000% (Gkritsi); Kazakhstan implemented harsher regulations on irresponsible mining following the mass exodus from China following 2021 (Lillis); and the U.S proposing a Digital Asset Mining Energy (DAME) tax of 30% on electricity costs used by mining firms (Ward). In general, this sentiment is held by world leaders as a U.N climate conference proposed a global tax on crypto currency mining, (Leahey). “Harry Sudock, Chief Strategy Officer at GRIID, points out that the bill could potentially deter efficient energy consumption and investment in new power generation. Sudock notes, “This one-size-fits-all approach could discourage rational energy consumption and investment in new power generation.”

These mining taxes see little effect on reducing emissions and pushing miners towards green energy directly. Typically when miners face these regulations, the margins are too low to stay in that area. Consequently, they leave often going to areas that have cheaper energy dependent on fossil fuels. An example of this is when China banned Bitcoin mining in 2021 citing “environmental concerns” though in reality it was more likely to be a way to control wealth leaving in and out of the country, (Volpicelli). This as a result moved Bitcoin miners away from surplus hydroelectric power in Sichuan, China to coal and natural gas power found in Kazakhstan and Texas, (Tabuchi). This is called “carbon leakage”: where carbon emissions are simply shifted to another place rather than being reduced overall.

I also personally believe that using taxes to push miners towards green energy will not work as cigarette taxes push lower consumption. They face different pressures. Cigarettes are localized–consumers will likely not move to where a cigarette tax is not in effect to buy cigarettes. Bitcoin mining is mobile–miners need to move to another location to stay profitable and the cost for doing so is much less than not. Cigarettes have little functional use besides an addiction–a tax on cigarettes curbs the main symptom of use. Bitcoin, as explained heavily in the CP, will always be in demand as a store of value fit for the digital age. As a result, miners will always be needed. This creates a stronger incentive than the disincentive created by taxes.

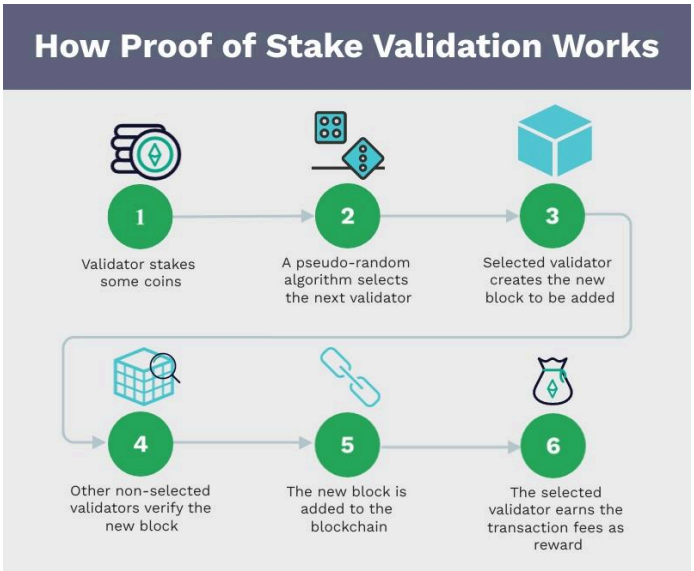
## 3b. Proof of Work (PoW) vs PoS (Proof of Stake)

Proof of Stake (PoS) and Proof of Work (PoW) are both ways to secure the blockchain, that is the ledger of transactions which cannot be reversed. These are also the ways that produce new tokens of the cryptocurrency as a reward for validating the transaction. For term clarification, a “miner” is the same as a “validator” just in different contexts. Typically a miner is used when referring to a PoW based system where a “validator” is referring to a PoS based system. They both attempt to achieve common objectives such as securing and verifying transactions fairly without a single entity controlling passes and vetoes.

To become a validator in a PoS system you need to “stake” your currency. Staking cryptocurrency is like putting money in a bank savings account. You “deposit” funds into the blockchain to help secure it. In return, you earn rewards, like interest, from transaction fees and new coins. You can withdraw your funds, but you’ll stop earning rewards and there may be a short wait. For security, just like a bank can freeze your account for fraud, staked funds can be “slashed” (partly or fully lost) if you act dishonestly, like proposing fake transactions. The

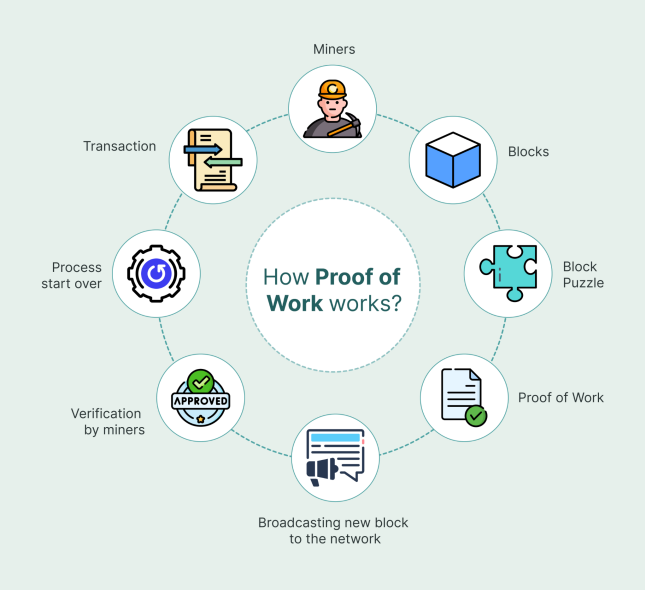
process for how a block–a group of transactions–is verified is as follows: A randomly chosen validator proposes a block after checking them. Other validators vote to confirm the block is valid. If most agree, the block is added to the blockchain, and the proposer gets a reward. Dishonest validators who try to cheat are punished by slashing their staked funds. A key insight here is that since validators who vote are chosen randomly, the more validators that belong to a single entity, the more sway they have on validating transactions. As stated previously, validators can be purchased with funds. The consequences of this will be discussed in further detail.

Figure shows infographic detailing PoS (Escobedo)




Bitcoin's transaction process is like a global lottery where miners compete to win prizes. Instead of depositing money like a bank savings account, miners buy "lottery tickets" by spending on powerful computers and electricity. The winner adds a batch of transactions (a block) to the blockchain and earns rewards (new Bitcoin and fees). Unlike a bank account, miners must keep spending to stay in the game, with no withdrawals. For security, cheating

miners who add fake transactions lose their investment, as the network rejects their blocks. Given the above, how a block is transacted is as follows: Miners collect and verify transactions from a pool, bundle them into a block, and race to solve a puzzle. The winner's block is checked by the network. If valid, it's added to the blockchain, and the miner gets a reward. Cheating wastes their resources, as invalid blocks are ignored. Other explanations online may use the term, "solving math puzzles" or something of the like. My opinion is that the "solving of puzzles" detracts from the real purpose of a PoW system, that is the equity and distribution of computing power. The "puzzles" are just a means to use electricity in a way that heightens the cost to perform an attack on the Bitcoin network and to incentivize honesty. Having Bitcoin cost money to create causes miners to want Bitcoin to have value. As a result if miners cause trust to waver in the Bitcoin network, Bitcoin's value will crash substantially. As described in the CP, Bitcoin's selling point is that of a trustless store of value. If any of these conditions are not met, Bitcoin has no use: no value.



As stated previously, both of these methods have similar end goals, that is to allow for a way to verify transactions without a single entity being able to approve or deny them. Although this is true, there is nuance to be had with respect to both of these systems as there are more factors at play than simply “decentralizing”. Bitcoin and the most famous PoS system, Ethereum, have different pressures that cause each system to have a different optimal way for validating transactions. Ethereum is a token used for developing smart contracts and securing transactions whereas Bitcoin's primary focus is a store of value with the ability to transact securely. Bitcoin emphasizes security above all else whereas Ethereum emphasizes scalability along with security. To improve one is to decrease the other.

Most literature involving PoS vs PoW involves citing security concerns and while that is an important topic of debate, it is not something that I have the capacity to answer even if given an entire paper dedicated to this topic. Instead I will give a practical argument to why a PoS switch to Bitcoin is simply unfeasible. Bitcoin’s development is run by a highly selective and above all conservative council. A large change in how the Bitcoin model works would require what is called a “hard fork” meaning that the new Bitcoin network that uses PoS will exist as a separate entity from the Bitcoin network with PoW. In general, the change would be too large for the possible benefits of a direct “emission” reduction due to the low usage of computation power in a PoS system, (Crypto with Lorenzo). As will be discussed in future sections, the demand for electricity consumption that is associated with a PoW system could be the driving force behind a green revolution. Moving to a PoS would completely remove this possibility.

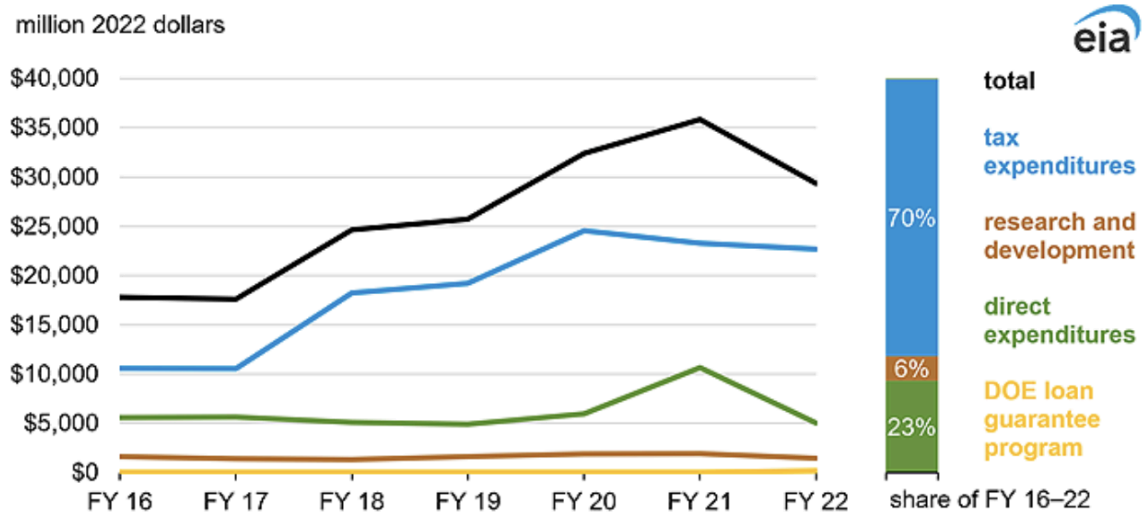
For those more interested in a decentralization argument, a brilliant argument is made by Tory Cross that ties into how Bitcoin can be used for renewable energy. The short version of his argument is that while currently mining is centralized, the competition from other industries that

need large amounts of cheap power and are able and willing to pay a higher price–such as AI– limit the growth of centralized Bitcoin miners. What will be available to Bitcoin miners is the scattered renewable energy sources that need any type of funding, not only increasing decentralization but increasing renewable energy usage not only for the Bitcoin network but for people world wide, (Cross).

## 4. State of Renewable Energy

Renewable energy as it is is broken. As seen on the figure below, subsidies have almost doubled from 2016 to 2022 from $20 billion to $40 billion. The share of energy produced in the

**Figure 1. Energy-specific subsidies and support, FY 2016–22**




Data source: U.S. Energy Information Administration, *Federal Financial Interventions and Subsidies in Energy in Fiscal Years 2016–2022*, Table 1 and Table A3
Note: DOE=U.S. Department of Energy.

U.S being renewable has grown from 15 to 24 percent from 2016 to 2024. At first it seems like this is a problem that goes away the more money that is thrown at it. While this may be true to some extent, one must wonder where does the money come from? Renewable energies are fighting an uphill battle. Not only do they need to contend with fossil fuel incumbent but also

they are subject to a higher upfront cost and maintenance than traditional power generation facilities like coal and natural gas (Regen Power) making it unattractive to investors. In short, renewable energy needs a way to support themselves, to be self-sustaining and practical. Though the climate is important, there are other matters of concern, all of which need money. To achieve any modicum of success, climate activists need to be pragmatic and think of more efficient solutions than giving more money and hoping.

## 4a. Demand Response

In Saul Griffith's book, "Electrify", Griffith makes the case for pursuing renewable energy by "electrifying" everything. That is to make as many of the technologies that rely on purely fossil fuels for power such as cars and heaters to be based purely on electricity. This electricity can then be made using purely renewable sources. For this plan to be successful, there must be a significant overhaul in our infrastructure to accommodate renewable energy's intermittencies. Therefore, following the basic laws of supply and demand, there must be a demand for non-constant and unpredictable energy, (Battes). If the demand is not met, this endeavor is simply unsustainable as subsidies must come from somewhere, already adding strain to the "grid of financial systems". As a result, to increase return on investment (ROI) and to pay back capital, many energy companies need to have a buyer of electricity when the usage is low.

To address this challenge, energy providers turn to Demand Response (DR) programs. These programs attempt to balance the grid by doing these two things: reducing demand during peak periods and encouraging usage when supply is abundant but demand is low. The most common interpretation of DR programs is reducing electricity demand during peak usage. These can be smart thermostats which automatically turn off A/C when a house drops below a certain

temperature or subsidies or other economic incentives like tariffs to reduce industry usage during peak hours, (Bertoli). The benefits for reducing power consumption during peak usage are obvious–less usage causes the grid to have less strain, reducing blackouts; reduces price due to lower demand and causes less of a need for "peaker plants", (Enel North America, Phoenix Energy Technologies).

A peaker plant is a power plant that is used only when demand for electricity is high, otherwise it is powered off. These plants typically rely on fossil fuels–this type of energy is the only source that can be supplied on demand as renewables like wind and solar are dependent on weather–and are expensive to turn on and off. A point of confusion is how is it sustainable to pay companies to not use electricity during certain hours? Despite intuition pointing to the contrary, it is actually the most cost effective solution as this cost of paying companies needs to be compared to the alternative–that is peaker plant associated costs. Demand response is economical because of its average cost of implementation. Paying companies is cheaper than having to pay maintenance costs, infrastructure upgrades and capital costs for a peaker power plant, (Hledik et al.).

While being an important part of the current energy regulation infrastructure, I believe that this aspect of DR programs is overstated and does not solve many of the key issues that face renewable energies and the climate crisis. This type of DR emphasizes cost mitigation over facilitating a transition to renewables. In other words, focusing too heavily on cost mitigation with the side effect of less carbon emissions blinds us to improving methods to organically catalyze the transition to clean energy and meet the world's ever increasing energy demands. The aspect of DR that I wish to highlight in the coming paragraphs is increasing electricity demand during low usage. The benefits of this method such as those discussed in detail above

are not as obvious; nevertheless, those often overlooked benefits are key to facilitating the green energy transition.

The first main benefit is that it provides additional funds to an energy production facility. A constant buyer for electricity during all periods of the day simply equates to more revenue for a company versus a loss. This is especially important for renewable energy because as explained in the previous section, renewable energies are heavily reliant on subsidies for maintenance and expansion. Batten states, "High upfront costs and slow returns (often 8–10+ years) limit cash flow for reinvestment. Extended payback periods deter investors and slow the scaling of renewable projects, delaying the transition from fossil fuels," (Batten).

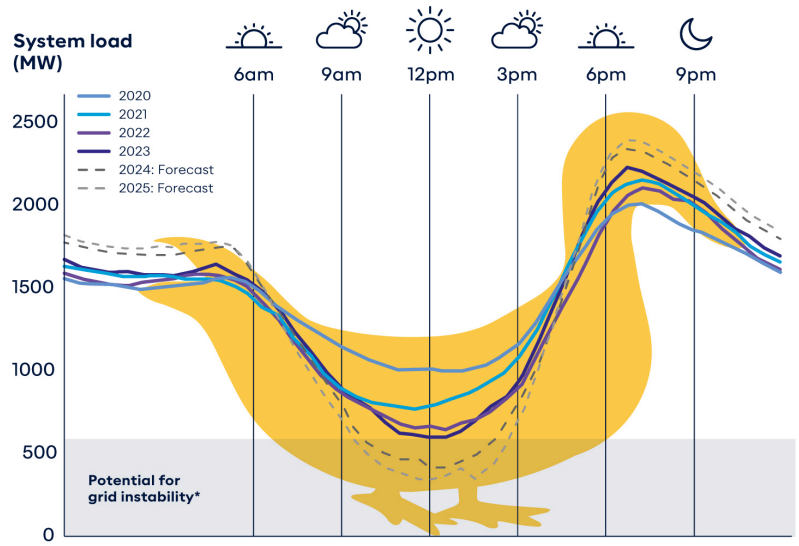
The second main benefit is that it reduces curtailment. Curtailment is when renewable energies need to halt power production. Power production is stopped because of two key factors: the grid being unable to handle the influx of excess power and the low demand for electricity at a given time. The first factor can happen because of abnormal weather conditions such as excess sun or wind or a period of low demand coupled with high energy generation. The second factor can cause prices to go negative, which entails that power producers would have to otherwise pay for the electricity they produce to be on the grid, (Gilam). Curtailment is especially a large issue because, "In some instances, California is producing so much solar energy that it has had to pay neighbouring states, such as Arizona, to absorb its excess energy, even with curtailment in place…Moreover, this energy sale does little to curb greenhouse gas emissions. Instead, Arizona Public Service curtails its own solar generation rather than fossil fuel power," (Gilam). Having a constant buyer of electricity, especially when supply exceeds demand, means curtailment is much less likely as there is an economic incentive to produce said electricity. It also implies that there should be a need for improving energy infrastructure rather than mitigating its existing

issues. The world's electricity needs are projected to accelerate in the coming years (IEA) and therefore, grid infrastructure needs to be changed. So not only does this type of DR initiative incentivize the production of green energy facilities, it also can provide the incentive to upgrade the existing power infrastructure to not only be more robust but to accommodate renewable energies. Combined with the extra revenue generated from these "buyers of last resort" this DR model could prove to be what is needed for the green transition.

The idea of a "buyer of renewable energy" has some potential candidates. Manufacturing industries such as metal, glass and various chemical manufacturers all consume vast amounts of energy. As such they benefit from such a DR arrangement: manufacturers get cheap electricity while energy producers do not have to curtail, (Johnson et al.). Nonetheless, these proposed benefits may not come to fruition as metal manufacturers need a constant and reliable supply of power. Given that curtailment arrangements mainly come from intermittent energies such as solar and wind, it seems unlikely that these would be the best fit. For more stable sources of renewable power however, this could show promise. For example, in Iceland the aluminum industry makes a substantial portion of the economy. This is because Iceland offers surplus power from stable renewable sources such as hydropower and geothermal. With the move from a fishing based economy to an aluminum based one, the economy has become in relative terms more stable than it was before. In spite of this apparent stability, Iceland's economy is becoming too dependent on one industry. As a result, the economy takes a downturn when aluminum goes down and it increases the leveraging power that aluminum producers have. As a result, Iceland is looking towards other sources of energy such as hosting data centers, (Grande).

Data Centers, especially given the rise of AI, will be a key consumer of electricity in the coming future (Skidmore); however, data centers typically need a constant uninterrupted supply

of power. This power is called “dispatchable” meaning that it is readily available to meet demand. Only coal, natural gas and nuclear power allow for an on demand tap. Other renewables such as wind and solar are referred to as Variable Renewable Energies (VREs), called such because they “generate electricity intermittently based on environmental conditions” (WTS Energy). From this, advanced storage systems are needed so that these VREs can supply a steady stream of energy to a datacenter. “In 2025, 37% of respondents expect their UPS[6] battery backup run times to decrease in the future, a notable rise from 26% in 2024. Meanwhile, 31% anticipate no change, down from 38% last year”, (“2025 Data Center Energy Storage Industry Insights Report”). From this, we can see that data centers are not a good product market fit for solar and wind energy. There needs to be a buyer of energy that can be flexible according to a “duck curve” and other unexpected power needs. Below a duck curve illustrates how electricity is used throughout the day. Higher loads that can cause grid instability are towards the bottom whereas lighter loads are on the top. From the above, there is a clear need for a buyer of electricity that is profitable, scalable and adaptable to changes in power consumption.




[6] Uninterruptible Power Systems

# 5. Bitcoin Demand Response Initiatives

Bitcoin mining is the best answer to the issue of a "buyer of last resort" for renewable electricity given current technology and demand. Bitcoin mining, unlike other "buyers of last resort" such as metal smelting and data centers, does not require a constant stream of electricity. As a result, Bitcoin miners can release energy back into the grid when needed. Because of this, Bitcoin miners can actually function as carbon neutral peaker plants. Power generation can be on full throttle during the entire day; excess power is sunk to Bitcoin miners; when more electricity is needed for consumer use, Bitcoin miners stop using power allowing all the power generated to flow to the grid only when needed. In other words, Bitcoin miners allow for a more efficient system to allocate power than traditional peaker plants that are expensive to turn on and costly to the environment while also allowing for more energy to be produced and sold overall. This is not just an idea peddled by evil Crypto miners spawned from the bowels of Twitter but rather one seriously brought into consideration by multiple peer reviewed academic journals.

## 5a. Academic Consensus

One common criticism is that Bitcoin cannot generate sustainable or meaningful economic returns, particularly due to its market volatility. There is, however, newly emerging peer reviewed evidence that puts into question the current narrative of Bitcoin mining. In a paper in ACS Sustainable Chemistry & Engineering, Lal et al. argue the following: "The findings indicated that bitcoin mining, an activity often criticized due to its energy-intensive nature, could serve as a bridge to foster investments in renewable energy. Bitcoin mining proved profitable in all of the examined planned installations, and by adopting this approach, investors could generate economic returns from otherwise unutilized assets…Therefore, integrating bitcoin mining with

planned renewable installations could enhance the economic potential of renewable projects during their precommercial operation phase and correspondingly mitigate the climate challenges tied to traditional mining practices," (Lal et al.). This study is only part of the movement that reframes the typically negative Bitcoin mining narrative: Bitcoin supports, rather than undermines, sustainability goals. Another study published in the Heliyon journal corroborates this economic viability of renewable energies funded by Bitcoin mining operations, concluding that "The outcomes indicate that initiating such a system at the start of 2020 with an investment of approximately $42 million could recoup its costs in about 3.5 years. In contrast, selling electricity to the grid would extend the power plant's return on investment period to 8.1 years," (Hakimi et al.). In the long term, Bitcoin will continue to grow. As discussed in much greater detail in the CP, Bitcoin fits the need as the trusted, divisible, portable and durable store of value for the digital age. Given the current regulatory climate and how money is being spent, Bitcoin will become more relevant so price increases notwithstanding the bubbles–all assets at some points are over and under valued. These studies show a clear benefit and need from an economic perspective for renewable energies to not only allow but to endorse Bitcoin mining.

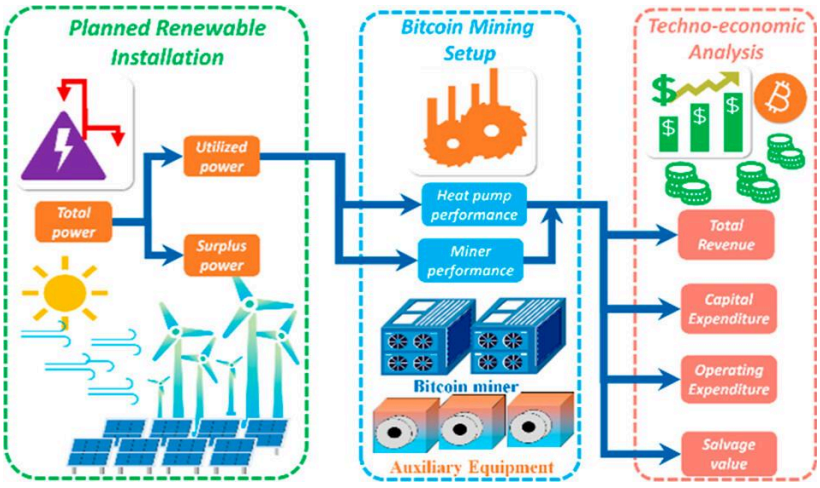



Image details how a Bitcoin mining setup and renewable power generation interact to produce gains. (Lal et al.)

Other peer reviewed studies from *Challenges* by (Ibañez and Freier) and a white paper from Duke (Norris et al.) corroborate the above findings as well as add that Bitcoin mining can also stabilize the grid by quickly shutting down when electricity is needed. Bruno et al.'s study published in the journal Resource and Energy Economics directly shows that Bitcoin with DR not only removes the need for gas peaker but also increases the total amount of energy available on the grid.

Table 1. Generation capacity with and without Bitcoin.

| Experiment | Solar | Wind | Gas CC | Gas Peaker | Carbon |
|---|---|---|---|---|---|
| **Baseline** | 48.68 | 34.24 | 27.47 | 5.62 | 46.43 |
| **Bitcoin** | 58.39 | 75.39 | 42.60 | 0.00 | 75.07 |
| **Bitcoin with Demand Response** | 58.48 | 82.92 | 29.42 | 0.00 | 48.67 |

*Notes:* This table shows the optimal long-run technology capacity across alternative experiments, as well as the resulting total annual carbon emissions. Capacities are in GW and carbon emissions are in millions of metric tons.

Image: (Bruno et al)

We see that solar power capacity jumps around 10 GW, Wind by around 50 GW while natural gas only jumps by 2 GW. For reference, a lightning bolt generates around 1.2 GW, enough to power 100 million LED light bulbs, (Mueller and Rumph).

I want to emphasize that Bitcoin mining will not take up consumer electricity. It is better to view Bitcoin mining as a buyer of electricity, one that on average pays a lower price. This is because Bitcoin mining is expensive, having tight margins on average and as such needs to keep costs low. Other consumers such as people who live in a town pay on average a higher cost. The decision solely depends on the energy company. It is clear that the energy company would choose to supply the energy to the consumer rather than the miner. Mining is just a way for

energy companies to maintain a higher average revenue given that energy can be sold where it could not be otherwise.

## 5b. Real World Implementations

Unlike the previous proposed solutions for metal and data centers, Bitcoin mining has already been used extensively in select regions to stabilize the grid and increase ROI for renewable energy in both developed urban and sparse rural areas. An example of this practice being used is in the ERCOT grid in Texas. ERCOT has jurisdiction over every major urban center in Texas: Dallas, Austin, San Antonio etc. as well as in total 75% of the land area in Texas, (ERCOT). Bitcoin mining company Jiachi West, has been operating with the ERCOT grid and has increased revenue of renewables by 12% and decreased curtailment by 4% as well as facilitated the construction and improvement of transmission lines by being a new, large and profitable business with energy needs, (Bitcoin Energy Summit). In 2022, former CEO of ERCOT, Brad Jones[7], labels Bitcoin mining as an opportunity for meeting the challenges of renewable energy. It allows for the quick allocation of power on and off the grid, keeps this process profitable and incentivizes the improvement of current infrastructure, (CNBC Television). In addition, 2024 data reports that Texas taxpayers have saved around 18 billion in taxes due to not needing the construction of a gas peaker plant, despite heavy opposition from fossil fuel lobbyists belonging to Berkshire Hathaway, (Dewhurst).

In Germany, Deutsche Telecom, Germany's largest Telecom company has started to set up Bitcoin mines to capitalize on unused wind and solar energy, reinvesting any funds for further renewable projects, (Sanderson). In Japan, Tepco, Japan's largest electric service company, is investing in similar projects to "encourage local production and consumption of electricity,"

[7] Brad Jones passed away on Nov. 8 2023 due to intestinal cancer

(Jones). In Norway when a Bitcoin mining system was removed, electricity prices increased by upwards of 20%. This is because the mining system was the main source of revenue for the electricity company. When that source of revenue disappears, the cost is pushed onto the consumers, (Guttormsen and Budalen). Though the main reason for the mining system being removed were noise complaints, this highlights the importance of implementing Bitcoin mining for these renewable purposes effectively rather than highlighting a fundamental flaw as shown with how successful it is in other areas.

The Bitcoin mining and renewable energy business model is also being used in Africa to make microgrids commercially viable. A microgrid is a self contained energy generation facility. These are typically found in remote, rural areas of the world such as Africa. Renewable sources like hydro are the main energy source. These microgrids are struggling to remain even sustainable as in rural areas, there is no large buyer of power that can supply the plant with revenue. This makes it so that to cover operational costs, these grids have to charge higher prices to already poor consumers. Research by the Tikula Research Network in Zambia shows that in a similar process to the figure shown in section 5a, Bitcoin mining can improve the economic viability of the microgrid. Microgrids could potentially serve electricity to up to 600 million sub-Saharan Africans, (KaPaipi). Because electricity can be supplied to those who did not have it before, not only does the quality of life go up drastically but new career opportunities are created. Some are created directly by Bitcoin mining such as local repairmen, others to facilitate power generation but many more are created from the abundance of opportunities that electricity provides, (BBC News Africa; Joe Nakamoto). With academic research backing up these already existing ventures, I believe that this is a pivotal moment in how Bitcoin is viewed in the climate

narrative. These demand response proposals should be getting more attention for what they are worth and communicated to the general public.

# 6. Further Applications of Bitcoin for Renewables

## 6a. Electric Heating

Around half of the world's energy is used for heating, contributing to 40% of all CO2 emissions. Half of the heat produced is for industrial purposes, 46% for residential use and the remaining for agriculture, namely greenhouses, (IEA, "Heat – Renewables 2019 – Analysis"). Though Bitcoin mining cannot directly solve this problem, it can tackle niche uses that would otherwise be forced to use fossil fuels. In other words mining turns electricity into heat with an added benefit that it produces currency. The process of Bitcoin mining generates excess heat that as a result can be used to heat up spaces. For example in Norway mining is used to dry wood (Boffey) and there are projects underway that promote using miners to take otherwise wasted renewable energy and convert it into heat for greenhouse use as seen below, (Bakardzhiev et al.).

In short, this aspect of Bitcoin mining is to recycle heat and energy, being more efficient with the resources at hand while promoting renewable sources of energy.

## 6b. Negative Carbon Emissions

Bitcoin mining is solely dependent on energy. Consequently, there is a market for finding unexploited sources of energy. One of these sources of energy is methane from landfills, which account for 17% of global methane emissions. Agriculture, which is majority in part by the infamous cow burps, contributes to around 37% of all methane emissions, (United States Environmental Protection Agency). Relatively speaking, landfills contribute half as much as agriculture does yet get much less than half the media attention. A study showed that not only was methane capture from landfills to Bitcoin mining economically viable but technology viable as well, (Marathon Digital Holdings). Below is a picture from the actual plant on sight:


Additionally, Bitcoin mining can also end gas flaring. Flaring is the burning of excess natural gas which is meant to break down the gas into less volatile and environmentally harmful substances. Despite this, gas flaring is still detrimental for the environment and causes more

toxic gasses than previously thought, (Pinnell et al.). Bitcoin mining can use natural gas similar to methane from landfills to power mining operations. In North Dakota, Bitcoin mining has already taken place near gas flares, combusting around 99% of gas as opposed to 92% in traditional gas flaring operations, (Skidmore).

## 7. Conclusion

In Daniel Batten's words, whose thoughts and corroboration of research have guided me through this endeavor, "Bitcoin Mining is Tier 1 Climate Action," (Batten). Current climate action needs to be changed–it is too focused on mitigating costs while being unstable economically speaking. Bitcoin mining brings feasible sustainability and economic benefits to renewables, promoting growth instead of stagnation. Just as Bitcoin itself is the store of value for the digital age, Bitcoin mining is the key industry for a renewable age. That being said, there are many challenges to overcome, mainly that of political resistance. Not only will these initiatives have to fight through a less informed, almost intentionally ignorant about anything crypto legislature but also through fossil fuels lobbyists whose best interests are in keeping the rotting status quo. I believe the solution is a constant push for the truth and the desire to improve our corrupt systems. Education is the key to that truth and at times, seemingly radical ideas should seriously be considered. At the beginning of my research for this paper, I believed that Bitcoin mining for ESG was something that was theoretically possible yet not implemented: evidence decided to flip that view. I believe that only now is the narrative starting to shift in the favor of Bitcoin and renewable energy, that Bitcoin mining may have been degraded for more than it was worth and that harsh punitive actions against mining have been extremely counterproductive. The written science is just catching up while the rule of thumb is waiting patiently.

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