REVIEW OF GEOTHERMAL ENERGY AS AN ALTERNATE ENERGY SOURCE FOR BITCOIN MINING

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ABSTRACT

This review article has highlighted the potentiality of using geothermal energy for bitcoin mining. Bitcoins are the future of digital payments and the backbone of intelligent and secure transactions. Still, bitcoin mining is a massive energy draw, making it less profitable and non-sustainable. The present paper outlines the cost, power consumption, and sustainability issues arising from bitcoinmining. It provides a rationale for potential geothermal energy application as an alternate source in bitcoin mining. We concluded that geothermal energy is a very cost-effective and environment-friendly option apart from many alternative energy sources available to bitcoin miners for mining purposes. Though geothermal energy is not entirely blame-free, it may create some geo-seismic issues in the long term, but overall, it is a great option. We must explore geothermal energy for bitcoin mining. We analyzed the research gap in this area and recommended more research.

Keywords: Bitcoin, Cryptocurrency Mining, Geothermal Energy, Alternative Energy, Green Energy, Sustainability.

INTRODUCTION

We are in a technology-enabled world. Technology has taken leaps and bounds in the past couple of decades, and almost everyone has gotten impacted by it. Digital payment is one area where wehave seen tremendous growth in technology. Cash transaction, which was a norm for any business earlier, is being replaced rapidly by digital payments. The number of non-cash transactions has gone up to 700 billion (Capgemini, 2021). This report also suggests that by 2025, instant payments and e-money payments will account for more than 25% of the global non-cash transactions, up from 14.5% in 2020. In a conventional digital payment, each party involved needing to maintain a payment record that needs to be validated in a clearing system (NYFED, 2019). Multiple record- keeping and validations via a clearing system make the transaction cumbersome and delated. One technology to overcome this situation is "*Distributed Ledger Technology (D.L.T.).*" It represents a mechanism in which data can be recorded and shared across multiple stores or ledgers concurrentlyon a network. D.L.T. also makes the transaction safe as any changes in the transaction need to be approved over the network. This makes the transaction over D.L.T. faster, easier, and secure. Faster, easier and secure are essential factors for any digital payment system. Cryptocurrencies are digital payment systems that use encryption techniques to control the creation of a monetary unit and verify the transactions using the D.L.T. methods. Creating a cryptocurrency is called Cryptocurrency mining, and it requires a massive amount of energy.

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Multiple researchers have estimated the power consumption of bitcoin (one popular variant of cryptocurrency), and the estimate of power consumption for bitcoin mining goes into gigawatt units (Kufeoglu & Ozkuran, 2019). There is a debate in the research community about the environmental impact of cryptocurrency mining. It is essential to understand how we can develop and further refine the process of bitcoin mining to reap its benefit but still keep the operation sustainable (Truby, 2018). The quest for alternate energy for bitcoin mining is natural. Some of thecommonly available alternate sources of energy are listed below (Table 1).

Table 1
AN INDICATIVE LIST OF A POTENTIAL SOURCE OF ALTERNATE ENERGY FOR BITCOIN MINING (AUTHOR'S DEPICTION)

Source	Alternate Fuel Characteristics	Challenges
Hydrogen Gas	Clean fuel, emits no harmful gases	Derived from Natural Gases
Wind/Tidal/Wave Energy	No excretion of harmful gases	Energy Transportation from generation plat is costly
Geothermal Power	Sustainable energy source	Location and Geographical condition dependent.
Hydroelectric Energy	It is a clean and renewable source ofenergy.	The hydroelectric power station adds a cost of transportation and energy storage issues.
Solar Power	Clean and renewable energy	Installation cost makes the power costly.
Nuclear Power	Massive availability	Operation risk

Out of all the possible alternative energy sources available at our disposal, we wanted to review the potential usage of geothermal Energy in Bitcoin mining, the opportunities and challenges around it.

Geothermal Energy refers to the power that comes from the Earth's subsurface. The energy is found far below in the Earth's hot molten rock, magma, and is renewable. Scientists have discovered thatthe temperature of the Earth's inner core is about 10,800 degrees Fahrenheit (°F), which has great potential if it can be tapped. Temperatures in the mantle range from about 392°F at the upper boundary with the Earth's crust to approximately 7,230°F at the mantle-core edge.

Low-temperature geothermal energy can heat greenhouses, residences, fisheries, and industrial processes. Geothermal Energy is most efficient when used for heating and generates electricity (Giungato et al., 2017). Many countries have already found a way to tap geothermal energy. Currently, this energy source is used in more than 20 countries over the globe. El Salvador becamethe first country to adopt bitcoin as legal tender alongside the U.S. dollar, which had served as thecountry's sole official currency for years. Daniel Alvarez, president of the state-run Lempa River Hydroelectric Executive Commission (C.E.L.), said El Salvador could generate electricity through hydroelectric, solar, wind, and tidal power projects. El Salvador government has started harnessing geothermal energy for bitcoin mining from a plant at Tecapa volcano, 106 kilometers east of the capital. The plant generates about 102 megawatts, and the government plans to add another five megawatts next year. At present, 1.5 megawatts are being allocated for bitcoin.

The United States is the biggest user of geothermal energy. "*The Geysers*" in California is the most extensive geothermal energy field globally, spreading over 117 square kilometers. It comprises 22power plants with an installed capacity of around 1.5GW. According to Elon Musk, geothermal energy can become the next significant energy source for mining bitcoin. Bitcoin mining needs a massive amount of electricity. Today, this enormous amount of electricity can only be generated by fossil fuels (Jayawardhana & Colombage, 2020). It harms the environment and is the cause of climate change. However, using geothermal energy mining of bitcoin can be environmentally friendly.

Geothermal Energy also can help to reduce the carbon footprint of bitcoin mining. Since the energycomes from volcanos or hot springs, it can be used 24×7 all seasons (Mnif et al., 2021). In

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this wake, the current paper analyzes geothermal energy as the primary power source of the bitcoin mining industry. Moreover, it will shed light on how this energy be put to use. The paper will focus on various limitations of geothermal energy, such as the cost, geographical location, etc. The paper also compares geothermal energy with wind power, solar energy, and hydro energy alternatives.

Feasibility Review of Geothermal Energy for Bitcoin Mining

Bitcoin mining and energy requirement: The first-ever Bitcoin was created back in 2009. However, the idea of creating virtual cash came in 2008 by a Japanese author. However, nobody knows about his real identity. In 2008 Satoshi Nakamoto, a presumed pseudonymous person, published an article about cryptocurrency. The thought behind it was to create an electronic peer-to-peer cash system (Zhang & Balogun, 2018). A virtual gold coin has real-world value just like traditional gold and can attract investors. Currently, Bitcoins have a maximum supply of 21 million. These coins are so hard to make.

Additionally, adding new Bitcoins to the market needs a lot of approval. Bitcoin miners are the one who decides how many bitcoins will be in the market. They also set the rules and regulations for Bitcoin exchange. And since these rules cannot be changed once they have been already regulated, that's all the supply there will ever be. However, maybe in the future, the Bitcoins mining industry will be more developed. There might be more Bitcoins available in the market (Balogun & Zhang, 2019). Usually, mining bitcoins means analyzing bitcoin transactions and recording them in the public block chain list. Through computers, it develops new coins by solving challenging and complex mathematical formulas or puzzles. These currencies are formed on a decentralized network, so they need to be mined first to use them. Miners use high-powered devices with highly high computing capability to analyze these transactions through the Bitcoin block chain. Many incredibly advanced algorithmic programs ascertain these block chains. The mining software needs 10 minutes to solve the complex program and develop a block. After that, they can be exchanged with cryptocurrency 24X7. El Salvador has become the first official country for mining bitcoins (Nanez Alonso et al., 2021). These programs run on several computers and require a lot of electricity. This is determined by hash rates of how much electricity is needed to mine bitcoins.

That is why mining hash-rate is vital. The more hashing power means the network is more secure. The hashing power of Bitcoin is still uncertain. However, it can be calculated based on the mined blocks and the blockchain difficulty.

Moreover, higher hash rates need higher power sources. This is one of many problems faced by many countries.

The power it needs, the more quickly the mining process can overlord the system (Rossi et al., 2019). The special computers used for mining cannot withstand that much load and cause massive blasts. It can cause the mining computers to overheat. They will need a cooling system and maybean ice room to mine bitcoins.

On the other hand, countries like Iceland and Switzerland can be the best places for mining bitcoins. Since these countries always have a minus temperature. Computers used in mining bitcoins do not face overheating issues often (Saleh et al., 2020). There is also a growing concern about harming the environment. Computers for mining bitcoins require a massive amount of electricity. Primarily, this electricity can only be generated by coal and fossil fuels. That is why 65% of Bitcoin mining happens in China due to the resources. However, it's also one of the main reasons for climatic changes in the environment, leading to excessive CO_2 emissions and contamination. Also, there are a limited number of resources. Coal and fuels are not renewable resources, and it costs way more. They need to be stored in an energy-storing machine. These machines are way too expensive for operators to afford (Rana et al., 2019). According to a CNBC

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study, cryptocurrency mining emits 35.95 million tons of carbon dioxide per year. That is almost the same as New Zealand's total electricity consumption. It is noted that a single Bitcoin can emit 200 kg of CO_2.

Higher price bitcoins can have more demand and more energy it consumes. It can become a genuine issue of sustainability. The electricity waste from the Bitcoins mining industry can harm the environment in more than one way. According to a study at the University of Cambridge, 76%of crypto miners use some form of renewable energy to fuel their mining system (Esmaeilian et al., 2020; Wagner et al., 2019). It needs more improvement. 39% of renewable energy is required in crypto mining. More than 20 countries over the globe use geothermal energy as a source of a heating greenhouse, producing electricity, etc. El Salvador has become the first country to account for geothermal energy as a primary mining crypto-currency source.

Geothermal energy as potential Source: Geothermal Energy can play a significant role in changing how bitcoins are mined. Geothermal Energy comes from within the Earth, and it is the only renewable energy resource, so it does not require heavy energy storage. The first evidence was found in Iceland, one of the world's most extensive mining facilities (Esmaeilian et al., 2019). However, some companies use other renewable resources like hydro, solar, and wind. But these resources are not as powerful as geothermal energy. So geothermal energy may become the future of the bitcoin mining industry.

As we find a temperature gradient in geothermal energy from the Earth's surface to the core, the heat can be drawn from various depths ranging from the upper crust to deep down from the mantle. Therefore geothermal reservoirs are classified as low-temperature reservoirs (<32F) and high- temperature reservoirs (>32F). A reservoir for commercial electricity production is generally a high temperature known as *"Hydrothermal Reservoirs"* Below is a map of geothermal energy across the United States (Figure 1).

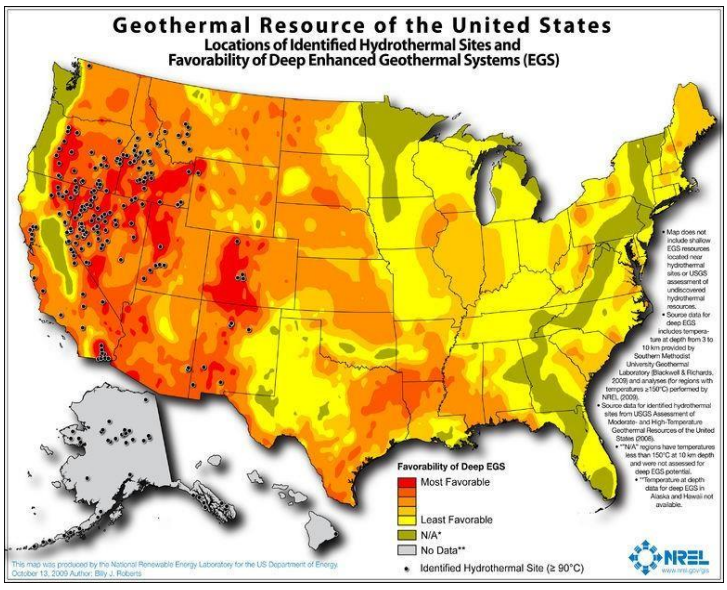

FIGURE 1
GEOTHERMAL ENERGY MAP (SOURCE: OPENEI.ORG)

Depending upon the extraction depth and technology, geothermal technology can be classified asfollows (Table 2).

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Table 2 GEOTHERMAL TECHNOLOGIES (AUTHOR'S DEPICTION)	
Geothermal Technology	**Distinctive Feature**
Hydrothermal Systems	Application of coincident heat, water, and rock at upper earth crust (<5km)
Enhanced Geothermal Systems	Hydrothermal reservoirs for commercial production.
Sedimentary Geothermal Systems	Production of electricity from medium temperature, trapped in the sedimentary deposits.
Direct-Use Geothermal Systems	Low-temperature water is used for the cooling effect.
Geothermal Heat pump systems	Space heating and cooling, using Earth's heat.
Co-Produced Geothermal systems	Hot water produced as industrial waste is used to produce energy.

Currently, geothermal energy is not used to its full potential. In fact, out of the major source ofenergies that Bitcoin miners are currently using, the geothermal option is completely untapped (Figure 2).

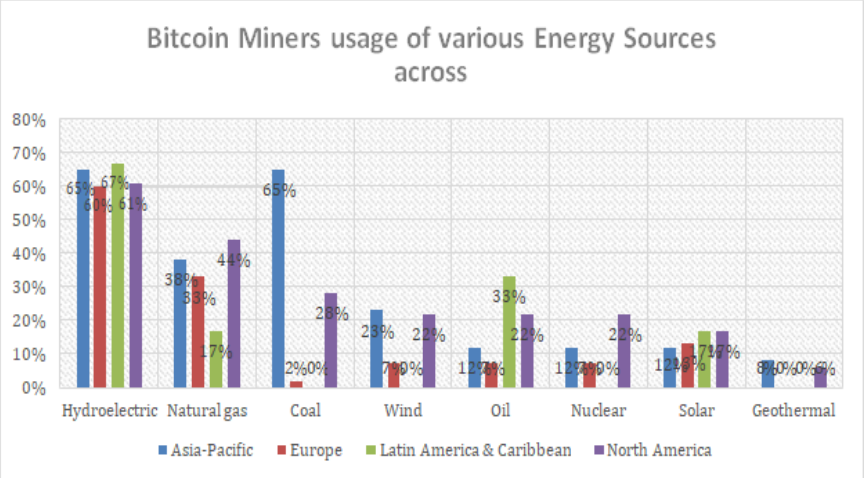

FIGURE 2
ENERGY SOURCES USED BY GLOBAL BITCOIN MINERS
(Data Source: https://www.visualcapitalist.com/visualizing-the-power-consumption-of-bitcoin-mining)

As shown in the graph above, the contribution of geothermal energy to bitcoin mining is very minimal and clearly, there is a potential to increase the geothermal energy's contribution to bitcoin mining.

Bitcoin Mining Defeats the Energy Transportation Problem

The energy distribution is technically challenging and incurs a high cost. A significant portion of the cost of electricity is the transmission and distribution cost (Energy Institute, 2018).

Geothermal Energy is very dependent upon particular geography and topography. Its geographical location restricts the adoption of this form of alternate energy for general users. Geothermal powerplants need to be near geothermal reservoirs. Unlike conventional or fossil fuel-fired power plants, geothermal power plants need to be near their availability. Not all state within the U.S.A. has the same level of geothermal energy availability. Below is an indicative map of the

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state ranking for geothermal electricity generation as of 2020 (Figure 3).

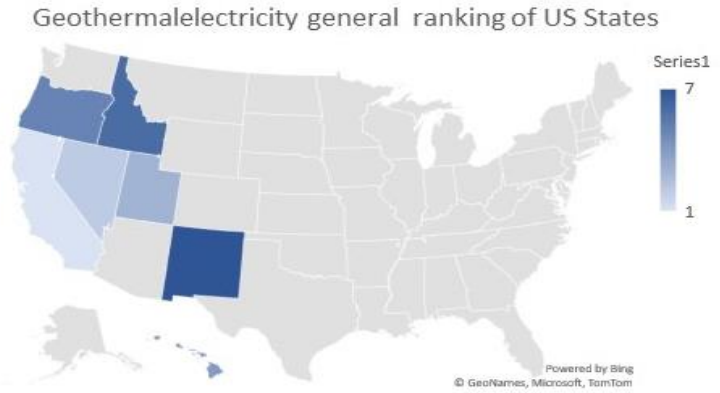

FIGURE 3
STATE RANKING FOR GEOTHERMAL ELECTRICITY GENERATION (AUTHOR'S DEPICTION BASED ON E.I.A. DATA)

As of 2020, the United States produced 17 billion Kilowatt-hours (kwh) of electricity concentratedin the following seven states only (Table 3).

Table 3
STATEWIDE DISTRIBUTION OF GEOTHERMAL POWER GENERATION (SOURCE: EIA.GOV)

States producing Geothermal Energy	Percentage of total geothermal Energy produced	Geothermal share of total state electricity generation
California	70.5%	6.1%
Nevada	24.5%	10.2%
Utah	2.1%	1.0%
Hawaii	1.2%	2.2%
Oregon	0.9%	0.2%
Idaho	0.5%	0.5%
New Mexico	0.3%	0.2%

Power distribution is a cost-intensive operation. Gladly, Crypto-currency mining has no geographic boundaries. This means Mining facilities can be set up anywhere (Pollani, 2021). For that, it has financial stability for the future. This opens up many opportunities for operators to invest in bitcoin mining. Geothermal Energy has a vast capacity for power supply. This can also generate electricity for computers to operate. It is more eco-friendly. So, there will be no issues with harming the environment. Also, mining is adaptable with the facilities available. If successfully implanted, geothermal energy can reduce the cost of mining Bitcoins (Mikhaylov et al., 2021). Though there is no data on how much charge it can reduce. Bitcoins mining involves two main factors, as mentioned above, hardware and energy. Geothermal operators have better capacity factors for the mining to be done successfully. However, there are a few problems whenit comes to hardware. Since geothermal has excellent potential, this can also cause the hardware to overheat. So geothermal operators have to do maintenance checks on the hardware more frequently. They also need to buy several parts beforehand to exchange them for the broken ones. It can be rather costly since these dedicated devices, and their inside components are expensive.

Mining bitcoins is a very tedious and complex task. The mining of bitcoins requisites possession of several resources, like computers with processors, graphics cards, and other hardware and software specially designed for mining bitcoins. Though it generates digital money

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without actually spending any real money, these resources are prohibitive and take a massive amount of electricity to run. It is no secret that Bitcoin mining eats up a lot of energy, causing an increase incarbon emissions.

Since the invention of Bitcoin currency, the mainstream media has been storming with its implications and role in the future. The recent trend in cryptocurrencies has become a global phenomenon. While digital currency is the future for e-commerce, Bitcoin mining is very costly and energy-intensive as it consumes nearly 47 terawatt-hours per year. The environmental impact of Bitcoin mining is the same as the carbon footprint of 6.8 million ordinary people. There are currently 25 million Bitcoins in the market, so one can imagine the extent of carbon footprint Bitcoin mining must be producing at this time. Unlike regular currencies, Bitcoin has a fixed emission schedule. This schedule indicates that the amount of Bitcoin minted with each new block gets cut in half every four years. This means there is a cap on the amount of Bitcoin that will ever exist. In this sense, like gold, Bitcoin is scarce. As a result, some people equate Bitcoin with digital gold and try to mine as much as possible out of greed, resulting in more environmental threats. We must look at energy sources that are not damaging to the environment and society and promote sustainability in Bitcoin mining and overall business.

Rising Cost of Bitcoin Mining, Making it A Less Profitable Business

According to Digiconomist, the Bitcoins miners get a total annual income of approximately 9,874,580,767 USD. As of 2021, it is the total value of mining rewards. However, the cost of electricity required to work is almost 6,755,868,299 USD dollars. This is because there is a fixed rate of 5 cents per kWh. It shows that Bitcoin's miners have to pay more electricity bills than the total profit. 68.42% of the total annual income goes to the production cost. That is why many miners prefer using renewable resources like geothermal energy. According to IRENA, 56% of green energy generates electricity at lower prices. In 2019, El Salvador became the first country to generate electricity with the help of geothermal energy. 21.17% of electric power was made using renewable Energy (Semenihin & Kondrashin, 2018). However, the bitcoin mining industry can change its way by implanting renewable geothermal energy as the primary power source to mine Bitcoins. It certainly is not perfect. Geothermal Energy is renewable and sustainable, has more capacity, and is more eco-friendly. However, the cost of successfully implementing geothermal Energy to Bitcoin mining facilities is prohibitive. Then how can the value of geothermal energy be measured?

Bitcoin is mined by powerful computers that help to generate new bitcoins. The current limit of Bitcoin is 21 million. After the limit is reached, there will be no mining. However, mining new Bitcoins is very costly and consumes a lot of energy. However, that issue can be resolved with the usage of geothermal energy. Geothermal Energy can change the way Bitcoins are mined. Since geothermal energy is natural and renewable energy, it does not consume much energy and leaves any carbon footprints. Receive for the environment and does not require heavy energy storage. Geothermal energies come from volcanoes and Earth's magma. So, it has geographical limitations. However, Bitcoin mining does not have any geographical restriction whatsoever. It can be done anywhere with proper equipment.

Cost-Benefit Analysis of Geothermal Energy *vs.* A Conventional Source of Energy

Shonder et al. (2003) reported in their research that when capital, operating, and maintenance costsare considered, geothermal heat pumps have the lowest life cycle cost, about 15% lower than the next most attractive option. In an analysis presented by Sahin and Topal (2017), they noted that geothermal energy positively contributes to the consumer and country's economy. Geothermal

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powerplants provide firm, 'always on' power, with capacity factors typically ranging between 60% to more than 905 depending on the site conditions and plat design (IRENA, 2019). According to Airconditioning, Heating, and Refrigeration Institute, the direct exchange (DX) geothermal design has the lowest operating cost in the industry. They have produced an excellent result shown below for an average 2600 sq. feet home for comparison purposes (Figure 4).

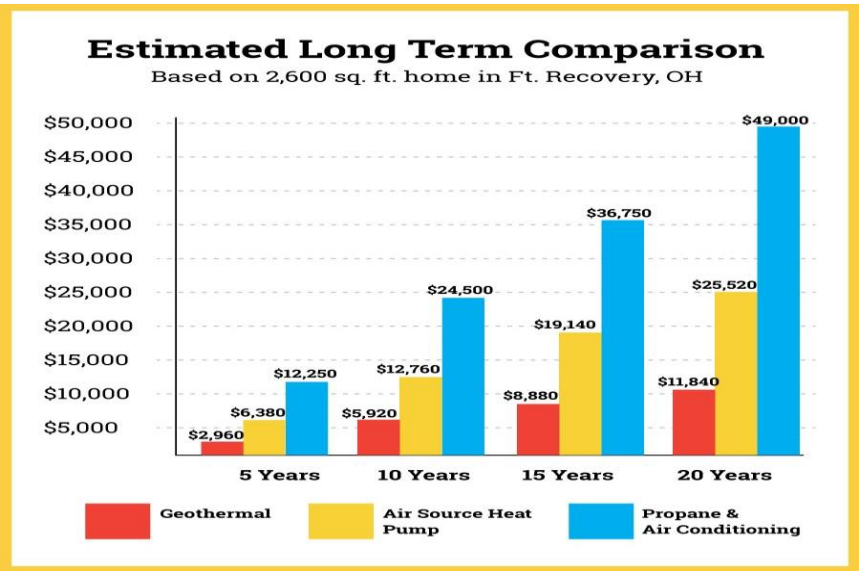

FIGURE 4
COMPARATIVE ANALYSIS OF HEATING COST
(Source: https://buschursrefrigeration.com/cost-savings-of- geothermal/

Geothermal Energy has a vast capacity for power supply. This can also generate electricity for computers to operate. It can also reduce the cost of mining. Bitcoin mining is adaptable with the facilities available. If successfully implanted, geothermal energy can reduce the cost of mining Bitcoins-many other renewable energies such as solar energy, hydro energy, or wind energy.

According to the current data, geothermal power plants can generate 0.0035 and 2 terawatts of power. It is more reliable and self-dependent. Unlike other green resources that depend on sunlight and wind, it can run 24×7 without depending on anything. It has multiple uses as well. People can use it for heating and cooling water, cooking, etc. But the primary use of geothermal energy is to generate electricity (Giungato et al., 2017). Unlike other sources, energy generated from geothermal energy can easily be analyzed. This means the operators can easily predict the power output with High accuracy. It does not require any fossil fuel or any other resources. Since geothermal energy can come from volcanoes. There are many explorations yet to be conducted.

This means geothermal energy has many opportunities in the future. It may change the mining industry. With the rapidly growing technology and development in Crypto-currency, geothermal energy can lead to a brighter future (Mnif et al., 2021). However, there are also many disadvantages of using geothermal energy as the primary power source for mining bitcoins. The most challenging issue faced by the mining industry is the geographical limitations of geothermal energy. Geothermal energy plants can be built far away from the volcano or where the energy is accessible. It cannot be transported or shipped to another place after restoring it.

Moreover, many countries don't have volcanoes, hot springs, or other ways to access geothermal energy. While it is true that geothermal energy is eco-friendly and does not emit any harmful gases, many toxic gases within the Earth's surface can affect the greenhouse and the

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surrounding atmosphere. However, it is still strategically lower than the poisonous gases emitted by fuel and Fossil fuels (Morozova et al., 2020). Since geothermal energy comes from Earth, it carries a high risk of causing earthquakes and volcanic eruptions. The earth plates are fragile and can trigger earthquakes. Geothermal Energy forces water into the Earth's crust to open up. However, these geothermal energy power plants are constructed away from crowds. So even if there is an earthquake, there will be little to no casualties. One of the enormous problems operators face is the cost of affording geothermal energy. Tapping geothermal energy is extremely expensive. It can cost an estimate of $2-$7 million with a 1megawatt capacity. However, geothermal energy is a long-term investment aside from all the costs. The energy needs to go back below the Earth to maintain the sustainability of geothermal energy fluid. It requires a lot of attention to maintain its sustainability. Geothermal Energy can also overload the dedicated devices used for mining bitcoins. They need to have maintenance checks more often. Checking up these devices and replacing them when broken can also be expensive (Zhang & Balogun, 2018). After evaluating the pros and cons of geothermal energy, it is safe to say that geothermal energy has more advantages than disadvantages. Geothermal Energy can become the next big thing in the bitcoin mining industry.

Assessment of the Relationship between Increased Carbon Footprints Due to Bitcoin Mining

As the demand for bitcoins is growing in the economic market, it also raises significant concerns about its negative impact on the ecosystem. Unlike traditional money, cryptocurrency is not made out of paper or metal. It is virtual money made by miners using complicated computing algorithms (Náñez Alonso et al., 2019 & 2021). It is the currency of netizens. However, it may be virtual but consumes a lot of power energy. Mining bitcoins use coal and fuels as the primary power source. This causes emissions of CO_2 so high that it can lead to global sustainability issues. Bitcoin is developed with high-quality computers with massive power capacity. These computers have dedicated hardware and software for mining Bitcoin by solving complex mathematical puzzles or algorithms. This process requires an enormous amount of electricity from fossil fuels, particularly coal. If the Bitcoin prices are higher, it is more likely to require a higher energy power supply. That way, miners can solve puzzles faster and can collect Bitcoin. A recent study shows that Bitcoin mining currently consumes an equal amount of power as the Netherlands annual power supply. Many major companies in the U.S. Bitcoin mining can have a considerable electricity waste. This also affects the environment.

Bitcoin mining can leave a massive carbon footprint. This high level of carbon footprint is almost the same as the annual carbon emission of London city. The city produces 98.9 megatons (Mt) CO_2. According to the Digiconomist blog, the transaction of one single bitcoin can have a carbon footprint of 359.04 kg CO_2. For instance, The annual carbon footprints for Delhi and Mumbai have been calculated as 69.6 Mt CO_2 and 32.1 Mt CO_2. It's almost the same as the amount of carbon footprint developed by 795,752 VISA transactions or 59,840 hours of watching YouTube. The amount of energy used in these transactions is the same as an average U.S. household over 25.91 days (Rossi et al., 2019). As a result, it is crucial to understand carbon footprint and harm the environment. A carbon footprint is a total amount of greenhouse gases (GHG) generated and directly and indirectly dependent on one person's choice, lifestyle, and activities. It is generally measured by equivalent tons of CO_2. It can be measured individually or separately. The sum results of the GHGs in a carbon footprint can come from the yield and consumption of antediluvian powers, food, manufactured goods, attack, roads, or transportation. Although it does leave some traces, it is pretty tricky to calculate exact figures of carbon footprint since there is no proper knowledge and data available on the complex relations between contributing processes-including the impact of natural methods that store or release carbon dioxide. Most bitcoin mining is being done in China due to fuel and coals.

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However, the current data shows how much the Bitcoin blockchain system can emit CO_2 (Saleh et al., 2020). The data indicates that by 2024 the annual energy con-consumption of the Bitcoin blockchain will reach 296.59 Twh and generate 130.50 million metric tons of carbon emission likewise in China. The number has already crossed the total greenhouse emission of the Czech Republic and Qatar in 2016. This pushes China to the world rank of 36th in carbon emissions. Also, the bitcoin mining industry ranked 10th among the other 182 Chinese prefecture-level citiesand 42 major industrial sectors. This is not to be taken lightly. The Carbon emissions generated bythe Bitcoin blockchain display a considerable reduction in S.R. and C.T. scenarios. Even though it can be seen as a positive impact of these carbon-related policies, the M.A. scenario will observe a significant rise in Bitcoin carbon emission to 140.71 million metric tons by 2025.

Environmental Aspects of Geothermal Energy

Geothermal Energy is clean and renewable. For example, the geothermal powerplant in Mexico only emits steam and water vapor. The main environmental effects of geothermal development aresurface disturbances, the physical effects of fluid withdrawal, heat effects, and the discharge of chemicals (Kristmannsdottir & Armannsson, 2003). Geothermal Energy is more eco-friendly thanconventional fuel sources such as coal and other fossil fuels. Moreover, geothermal power plants leave less carbon footprint. It emits little to no harmful gases that can affect climate change. It extinguishes 97% sulfur and 99% carbon dioxide. Binary plants only emit hot steam. This energyuses continuous heat and power from within the Earth. It is also a renewable resource to last longerthan conventional sources. There will always be an unlimited amount of supply. The heat from within the Earth is naturally replenished as well. So, it's both renewable and sustainable (Chen et al., 2021). A recent study showed that only 15 terawatts of energy are consumed globally. Geothermal Energy has more capacity than that. Currently, most of Earth's reservoirs can't be accessed as there is no data regarding geothermal energy's total capacity. However, this will change in the future with ongoing research on geothermal energy and the development in the Bitcoin mining industry.

Gaps in Research

The study outlines the gap in the study where it focuses on outlining alternative mechanisms for mining bitcoins that require a comparatively lower volume of energy. That is why many operators of the bitcoin industry are switching to eco-friendly methods to mine bitcoins. As the advancement in technology is thriving, there have been many experiments regarding the cryptocurrency industryon minimizing the carbon emissions from bitcoin blockchains. Including big firms in the crypto market can solve the problem (Pollani, 2021; Linkov et al., 2018). Big firms can invest more in renewable energies topromote "*green bitcoin*" since it is more expensive. The study also discusses bitcoin's sustainabilityissues resulting from the mining of bitcoins in large proportions. Many sustainability experts believe that big firms can buy carbon credits to reduce the effect of bitcoin mining. It istheoretically possible to track the Source of bitcoin. It allows green Bitcoins. Governmental policies on Climate change can also help in that. Miners can use renewable resources to mine Bitcoins. Geothermal Energy is one of the best quality resources for mining higher price Bitcoins. El Salvador, Siberia are developing ways to access renewable energy, i.e., hydropower, wind power, and solar power, to mine Bitcoins instead of fossil fuels. This will reduce the carbon footprint of bitcoin. Many are using the heat generated by mining in agriculture and heating greenhouse. Many operators believe that power generated by flare gas can also be used as an alternative to fuel.

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FINDINGS AND LIMITATIONS

The paper has analyzed how renewable energy sources can improve Bitcoin mining and reduce its carbon footprint. Geothermal Energy is eco-friendly and renewable energy. It has sustainability and a High-Power capacity to mine Bitcoin. We concluded that:

1. Bitcoin mining is an energy-intensive exercise, and it needs an enormous amount the electricity to power up the Bitcoin mining procedure.
2. Geothermal energy has great potential, and a significant source of geothermal energy is still untapped for several reasons; the most important one is geographical limitations.
3. Bitcoin mining is agnostic to the geographical locations; miners can stay close to the geothermal power plant and enjoy a cheaper and constant flow of electricity as the distribution cost component of the electricity bill will be minimum.
4. The rising cost of Bitcoin mining is shrinking the miner's profit. The cost of electricity is eating up the benefits they might reap. A cheaper source of electricity is a need of the hour.
5. Geothermal energy has a minimum life cycle cost compared to all alternative energy sources.
6. Bitcoin mining with conventional energy sources is not sustainable. It creates a large carbon footprint, seriously impacts the environment, and defeats the sustainability goals.
7. Geothermal energy is environmentally friendly. Compared to the conventional power generation process that emits hazardous GHG (Green House Gases), a typical geothermal power plant extracts only water vapor as industrial waste.
8. Geothermal energy is also not free from any negative connotations. There are some seismic issues around it.

While this is true, there are many backsides to geothermal energy as the primary Source. Many analysts believe that geothermal energy can be considerably expensive (Pollani, 2021; Jon, 2018). The cost of sustaining this energy can be more than the manufacturing cost of one single Bitcoin. On the other hand, geothermal energy does not cause any climate change. But excessive use of geothermalenergy can cause earthquakes and volcanic eruptions.

CONCLUSION

Geothermal Energy is a renewable source of energy. Bitcoin mining is the future and cannot avoid. The future of the payment system depends on bitcoin, and mining bitcoin won't stop. We need more search in Bitcoin mining to ensure it is cost-effective, profitable, and environment friendly. Global leaders, Organizations, and agencies need to come together and encourage the research of applicability of alternative sources of energy for Bitcoin mining in general and application of geothermal energy.

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