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Environmental Issues & Implications of Cryptocurrency Market: A Theoretical Study

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Abstract--- *This paper decides to discuss the Environmental Issues & Implications of Cryptocurrency market. Since many studies and research is already happened regarding Cryptocurrencies and Blockchain working methodologies; but only a couple of papers discussed the environment perspectives and its impact of the growth of these digital asset modules. It is very hard to believe that the world without the Internet, Air Conditioner, Vehicles or the Cash. Technology plays a major role in every individual life and environment. Now the serious implications are Environmental issues. People are living longer with technology and anyway it does come with a price. Cryptocurrency or Virtual currencies are the money of the future. In this digital age, Cryptocurrencies become a global phenomenon. Even though Bankers, Scientists, and developers are having limited knowledge about cryptocurrencies. Despite its virtual nature, Bitcoin mining requires a massive amount of processing power and in line, energy. One of the major problems is still not being effectively addressed, namely, the energy consumption of transacting across many of the biggest Blockchain networks in the industry. This issue, which has grown exponentially over the past few years, shows no signs of slowing down and continues to cause environmental degradation along the way. Since this paper provides the current insights of the environmental issues and discusses the possible alternatives are needs to adhere in the future*.

Keywords--- *Cryptocurrency Market, Bitcoin Currency (BTC), Blockchain, Environment Issues, Implications, Energy Consumption.*

I. INTRODUCTION

As per Satoshi Nakamoto, who is the unknown person or people who are developed Bitcoin, a Cryptocurrency is nothing but electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party. New coins created by an algorithm with the insertion of cryptography. Cryptocurrencies have come a long way from their relatively ambiguous origins. While in the financial institutions has a concern of digital currencies as tools for criminals, terrorists or rebellious individuals frustrated with traditional money, in meanwhile the industry has significantly progressed in establishing as a legitimate potentially. This new pace of digital asset and payment system, based on the decentralized peer-to-peer network, in 2009.

In 2017 Japan became the first country in the world that legalized Cryptocurrency such as Bitcoin and Ethereum, on the official level. That allowed many online stores across the country to accept payments in tokens. Other countries also didn't want to stay aside from this global trend. The G20 is currently working on the possibility of crypto-market regulation. However, there are some countries that ban Cryptocurrencies on their territories. For

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example, financial firms in China are not allowed to hold Cryptocurrency or lead any ICO, initial coin offerings. In Venezuela, Cryptocurrency miners are prosecuted.

One of the greatest invention in the world is Electricity. Now, we do more and more, the usage of electricity is extended to a greater level. Most of our electricity is generated from non-renewable sources that pollute our air and water. As the demand for electricity increases, the damage to our planet also increases. Even though we care about our world, but we are not willing to give up the luxuries of electricity. Cryptocurrency mining demands an extremely high and ever-increasing amount of electricity. Green energy production is one of the missions of the world especially Blockchain and Cryptocurrencies marketers.

One of the major problems is still not being effectively addressed, namely, the energy consumption of transacting across many of the biggest Blockchain networks in the industry. This issue, which has grown exponentially over the past few years, shows no signs of slowing down and continues to cause environmental degradation along the way.

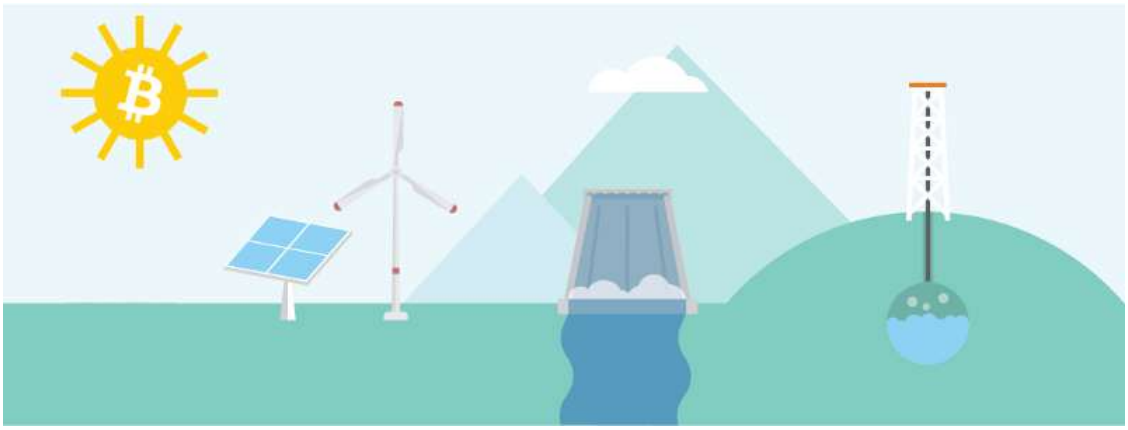

Fig. 1: The Environmental Impacts of Bitcoin

Despite being called a hoax by figures such as Jamie Dimon, Bitcoin has continued to grow to over $18000. On top of being feared as a bubble or a tool for criminals, the Cryptocurrency has also generated considerable concern for environmentalists. Despite its virtual nature, Bitcoin mining requires a massive amount of processing power and in turn, energy.

According to Digiconomist, Bitcoin's estimated annual electricity consumption as of December 18th was 34.86 TWh. To put that into perspective, if Bitcoin's network were a country, it would rank 60th in terms of global energy consumption, on par with the nation of Bulgaria. The energy used by a single Bitcoin transaction could power the average U.S. household for eight days.

This daily consumption of power translates to 118.36 kg of CO2 being emitted per transaction, or 11083 kilotons annually. If we follow the EPA's estimate that the average car emits 4.7 metric tons of CO2 each year, then Bitcoin has the same environmental impact as approximately 2.358 million cars annually. These statistics have caused many environmentalists to fear the rise of Bitcoin and other Cryptocurrencies, as they are creating emissions and hindering the fight against global climate change.

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II. LITERATURE REVIEW

"Virtual currencies, perhaps most notably Bitcoin, have captured the imagination of some, struck fear among others, and confused the heck out of the rest of us." quoted by Thomas Carper, US-Senator. While the issue of environmental sustainability of Cryptocurrencies is under debate in the media (The Guardian, November 2017), academia has been relatively slow to address this urgent issue. Only a couple of papers discussed the impact of the growth of these digital asset classes on the environment. Sustainability in the context of environmental and economic aspects have been analyzed by Vranken (2017), and the results provide an opposite conclusion to the popular belief of the developments in Bitcoin mining hardware that briefly outline alternative schemes that are less energy demanding. He finally looks at other Blockchain applications and argues that energy consumption is not of primary concern of his paper. Harwick, C., (2016) states that the sustainability of Cryptocurrencies is depending upon the amalgam of environmental, economic, financial and ethical aspects.

Despite these issues, the major draw of China continues to be the electrical costs. This has been the case for several years as the average national rates in both India and China have hovered at approximately 8 cents / kWh which is significantly lower than others such as Denmark at 41 cents / kWh.[2] While Moses Lake in Washington State has made headlines for its 1.7 cents / kWh rates which have attracted numerous pools, in China, some commercial operators can get electricity for 3 cents / kWh.[3] Out of all currently deployed consensus algorithms, Proof-of-Work achieves the highest degree of trust-minimization [2]. In the future, however, Cryptocurrencies might thrive in such an environment because, unlike the paper-money alternatives, allow users to make digital payments. In Kenya, where many people are unbanked but have cell phones, Vodafone's m-pesa system has taken off (Burns 2015). If incumbent money were especially unstable, such users might opt to use their phones to transfer Cryptocurrencies. KJ O'Dwyer & D. Malone (2014) states that to look at the energy consumption of Bitcoin mining and consider if and when Bitcoin mining has been profitable compared to the energy cost of performing the mining, and concluded that specialist hardware is usually required to make Bitcoin mining profitable. They have discussed that the power currently used for Bitcoin mining is comparable to Ireland's electricity consumption. Rogojanu and Badea (2014) explore the advantages and disadvantages of Bitcoin and compare it with other alternative monetary systems.

Ciaian, Rajcaniova, and Kancs (2016) examine Bitcoin price formation by focusing on market forces of supply/demand and digital currencies specific factors. Few studies have emerged from the view that Bitcoin presents an alternative to conventional currencies in times of weak trust, such as during the global financial crisis in 2008, thus referring to Bitcoin as digital gold (Rogojanu and Badea 2014; Popper 2015). Others have examined the benefits of including Bitcoin in an equity portfolio (Halaburda and Gandal 2014; Eisl, Gasser, and Weinmayer 2015). Baur, Lee, and Hong (2015) argue that Bitcoin is a hybrid between precious metals and conventional currencies. They also highlight its role as a useful diversifier (i.e. uncorrelated with traditional assets) and an

[2] See Determining Electrical Cost of Bitcoin Mining by Ruben Alexander and The Average Price of Electricity, Country by Country from The Energy Collective

[3] Ignoring cooling requirements and management overhead another infrastructure issue is that this build-out needs approximately a $100,000 transformer for every 1 megawatt. See also Bitcoin Miner Taps Dad's Power Plant in Virtual-Money Hunt: Tech from *Bloomberg* and The Other Bitcoin Power Struggle from *Businessweek*

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investment. If Bitcoin is regarded as an investment, then we need to know more about its properties and particularly about its relation to other assets. However, what renders an asset interesting from diversification and impact on environmental issues and energy consumption.

Bitcoin Mining in a Nutshell

The Bitcoin ecosystem is a network of users that communicate with each other using the Bitcoin protocol via the Internet. The Bitcoin protocol is available as an open source software application and allows users to store and transfer Bitcoin for purchasing and selling goods, or to exchange Bitcoin for other currencies. The issuance of Bitcoin takes places in the network while handling transactions in a process called Bitcoin mining. The Bitcoin network started in 2009 and ever since Bitcoin has been the most popular decentralized currency. In January 2017 there was 16 million Bitcoin in circulation with a total value of roughly 16 billion US dollars, although the exchange rate of Bitcoin has shown very large fluctuations.

The statistic presents the total number of Bitcoin in circulation from the first quarter of 2011 to the fourth quarter of 2018. The number of Bitcoin has been growing since the creation of this virtual currency in 2009 and reached approximately 17.45 million in December 2018.

Mining has two purposes:

- Limit the creation of new coins
- Verify new transactions and prevent malicious changes to existing transactions

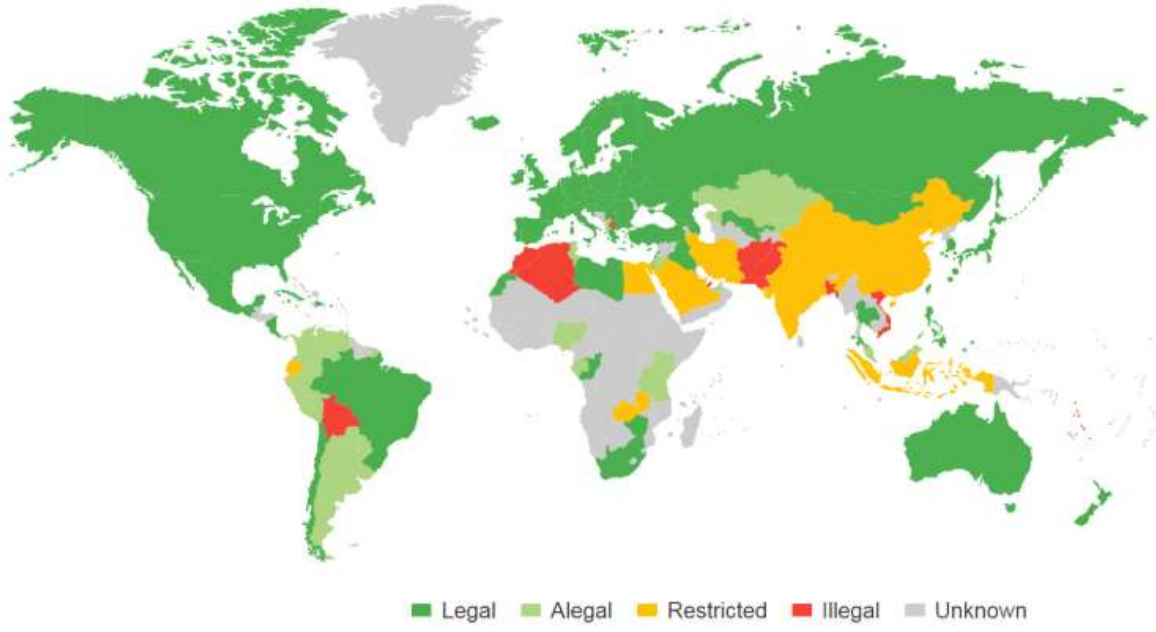

Fig. 2: Bitcoin Legality by Country

Source: moneycontrol.com

The majority of "uncertain" countries where no regulation is implemented do not recognize Cryptocurrencies as a legal means of payment and have expressed concern about the risks the currencies present, even if they have not

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prohibited the use for a personal medium of exchange. Such countries include Indonesia, Lithuania, Malaysia, the Philippines, Slovakia, South Africa, South Korea, and Thailand. The governments of Lithuania and Malaysia do, however, characterize Cryptocurrencies as perspective technology worthy of future investment.

In contrast, some others, such as Denmark, Ireland, and Colombia, have asserted that Bitcoin is not a currency and the governments will not regulate a digital currency market. Brazil, Hong Kong, and Pakistan view the Cryptocurrency market as too nascent to regulate, regardless of the official positions on these types of currency. Still, others prefer to take no official position on Cryptocurrencies, including Chile, Cyprus, Greece, Malta, Nicaragua, Portugal, and Turkey.

For those countries with some official recognition of Cryptocurrencies, several approaches for regulating the market are being tested with varying levels of favorability toward fostering the growth of the digital currency[4]. No consensus approach has yet emerged from amongst early regulators, including India, New Zealand, Poland, and Switzerland, among others. Some countries, such as the United Kingdom and Italy, are following a model under which business operations based on Cryptocurrencies are taxed as such.

As per Fig 2, in the world, some of the countries are still restricted and some of the countries announced as Bitcoin as illegal. In this category Unknown countries too in the list. On the other hand, the number of Bitcoin circulations are wider in the world. As shown in Fig 3, the Bitcoin circulation worldwide from 2011 to 2018 is mentioned.

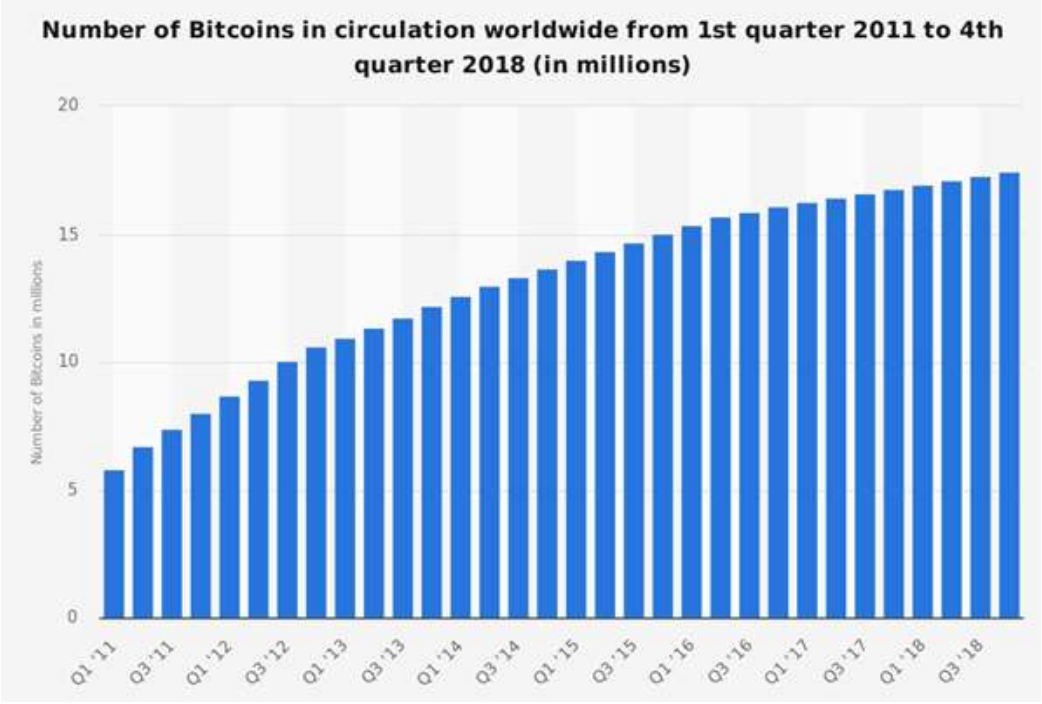

Fig. 3: Bitcoin Circulation Worldwide from 1st Quarter 2011 to 4th Quarter 2018 (in Millions)

Source: Blockchain – Statista 2019

[4] Regulations evolve rapidly, so the analysis can differ from recent developments.

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In Fig 4 states that the total USD value of trading volume on major Bitcoin exchanges. The total USD value of Bitcoin supply in circulation, as calculated by the daily average market price across major exchanges.

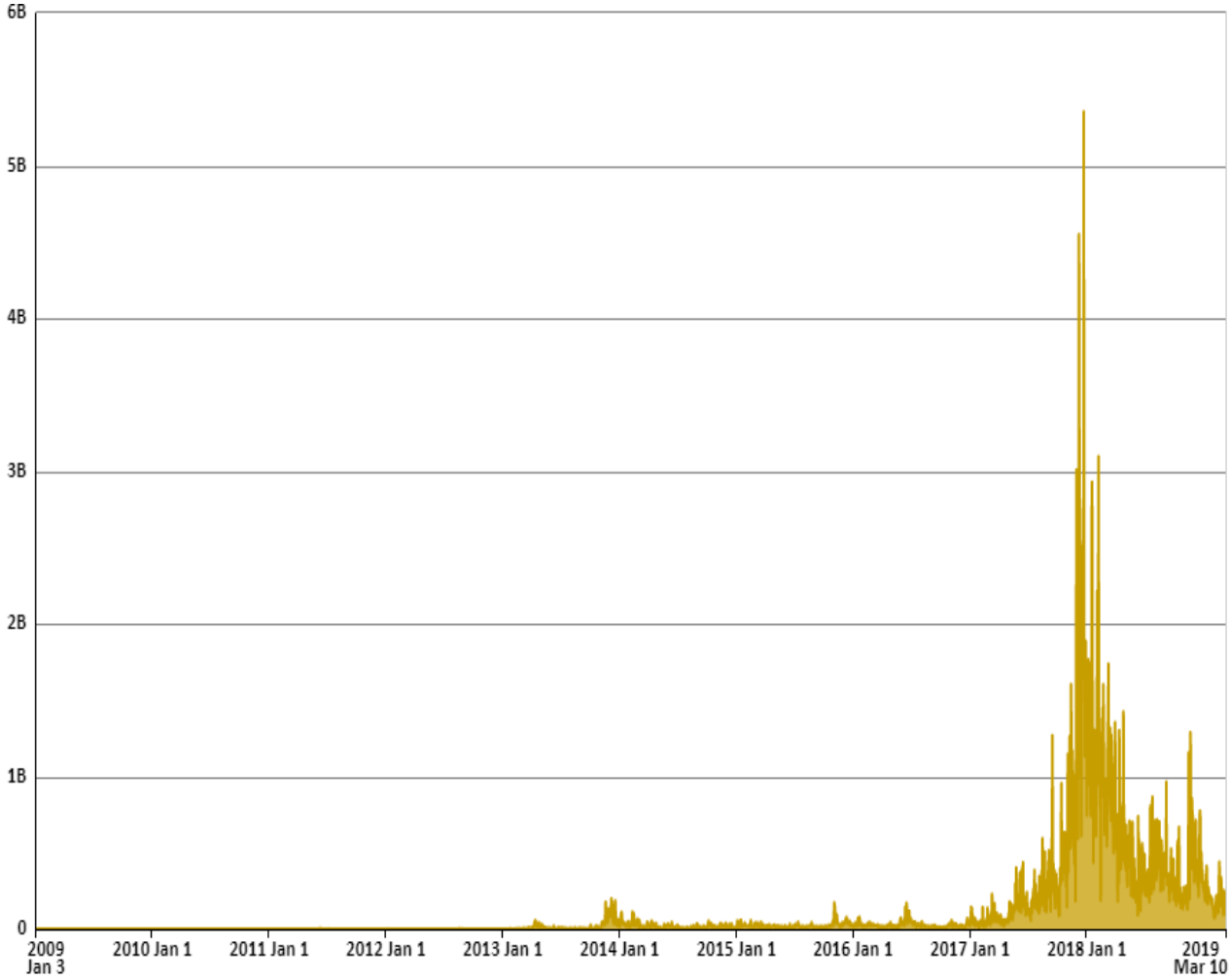

Fig. 4: USD Exchange Trade Volume

Source: https://knoema.com/rilqhnd/bitcoin-currency-statistics-2009-2018

Energy Consumption

Mining is the process of adding transaction records to Bitcoin's public ledger of past transactions. The blockchain serves to confirm transactions to the rest of the network as having taken place. Bitcoin nodes use the blockchain to distinguish legitimate Bitcoin transactions from attempts to re-spend coins that have already been spent elsewhere. This process is energy-intensive and often causes power consumption issues.

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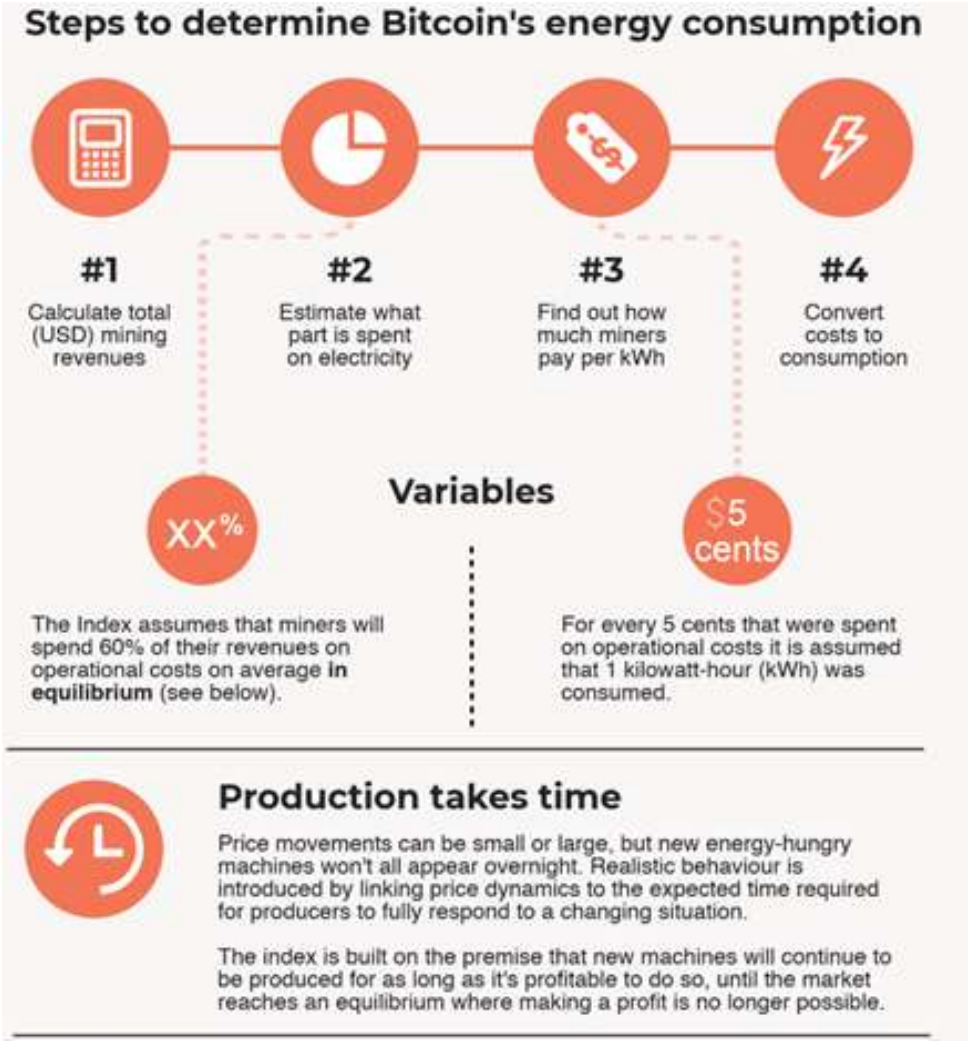

Fig 5: Bitcoin Energy Consumption Index

Source: http://bitcoinenergyconsumption.com/

III. Environmental Issues & Implications of Crypto and Blockchain Market

A majority of Cryptocurrencies operate under a proof-of-work (PoW) consensus mechanism which requires computing extremely energy intensive mathematical problems in order to verify and secure transactions on the Blockchain. Creating a self-sustaining project in the crypto and Blockchain market is the first step to encouraging further innovation and disruption in the renewables sector. The biggest fact is that we need to energy to live our lives especially as technology advancement continues to innovate and some time to create.

Today, the total energy consumed by the Bitcoin network in one year can power more than 6.7 million homes in the United States alone. Some states want to tax Bitcoin mining as a result of the increase in electricity costs to residents in areas where mining is occurring, and the country of Iceland is likely to use more energy to power Cryptocurrency mining than for powering homes this year. These are all signposts of the negative environmental impact Cryptocurrencies are having on the world, a problem which needs addressing before it's too late.

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Table 1: Bitcoin's Energy consumption / Electricity Consumption

Description	***Value***
Bitcoin's current estimated annual electricity consumption[5] (TWh)	47.73
Bitcoin's current minimum annual electricity consumption[6] (TWh)	45.94
Annualized global mining revenues	$2,706,505,667
Annualized estimated global mining costs	$2,386,362,512
Current cost percentage	88.17%
Country closest to Bitcoin in terms of electricity consumption	Singapore
Estimated electricity used over the previous day (KWh)	130,759,590
Implied Watts per GH/s	0.113
Total Network Hashrate in PH/s (1,000,000 GH/s)	48,124
Electricity consumed per transaction (KWh)	405
Number of U.S. households that could be powered by Bitcoin	4,419,190
Number of U.S. households powered for 1 day by the electricity consumed for a single transaction	13.68
Bitcoin's electricity consumption as a percentage of the world's electricity consumption	0.21%
Annual carbon footprint (kt of CO2)	23,386
Carbon footprint per transaction (kg of CO2)	198.33

It is clear that the current processes are not sustainable, and they will only get worse. To put it simply, as more and more Bitcoins are mined, the mathematical problems that computers must solve to generate more Bitcoin will get increasingly difficult, requiring even more processing power as a result. On top of the amount of energy required to mine Bitcoin, the way it is sourced only threatens the environment further.

Fig 6 shows that a growing concern is a fact that the majority of Bitcoin being mined in China, where electricity is super cheap but is generated by dirty coal power plants. Despite the Chinese government's focus on increasing the implementation of renewable energy systems, it will be challenging to persuade miners to switch over from the inexpensive power of which they currently take advantage.

Fig. 6: A Coal Power Plant in China

[5] The assumptions underlying this energy consumption estimate can be found here. Criticism and potential validation of the estimate is discussed here.

[6] The minimum is calculated from the total network hashrate, assuming the only machine used in the network is Bitmain's Antminer S9 (drawing 1,500 watts each). On February 13, 2019, the minimum benchmark was changed to Bitmain's Antminer S15 (with a rolling average of 180 days).

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China is the top country by CO2 emissions from fossil fuels in the world. As of 2014, CO2 emissions from fossil-fuels in China was 2.81 million thousand metric tons that account for 30.76 % of the world's CO2 emissions from fossil fuels.

		2014	2013	2012	2011	2010	2005	2000	1990
1	China (Mainland)	2,806,634	2,797,384	2,734,817	2,654,360	2,393,248	1,608,115	928,601	666,057
2	United States Of Ameri...	1,432,855	1,406,916	1,396,083	1,442,509	1,471,375	1,578,873	1,552,682	1,315,354
3	India	610,411	554,882	550,451	502,257	468,964	333,396	281,389	168,845
4	Russian Federation	465,052	485,018	499,272	480,885	455,558	440,439	424,843	–
5	Japan	331,074	339,928	335,470	324,809	319,505	337,948	332,841	298,931
6	Germany	196,314	206,521	201,762	199,754	206,943	217,393	226,337	–
7	Islamic Republic Of Iran	177,115	169,015	166,828	160,637	156,267	127,845	101,510	57,394
8	Saudi Arabia	163,907	147,545	154,034	136,318	141,394	108,438	80,975	50,669
9	Republic Of Korea	160,119	161,576	159,249	160,731	154,545	126,240	122,051	67,342
10	Canada	146,494	141,031	141,112	146,472	145,806	152,009	145,727	118,675
11	Brazil	144,480	137,354	128,178	119,829	114,468	94,712	89,442	56,964
12	South Africa	133,562	127,182	127,835	128,329	129,288	113,694	103,263	85,439
13	Mexico	130,971	133,717	135,349	132,105	126,618	127,178	108,640	86,836
14	Indonesia	126,582	133,686	173,733	164,621	116,924	93,262	71,835	40,787
15	United Kingdom	114,486	124,966	127,781	122,124	134,499	147,963	147,746	151,602

Fig. 7: Fossil-Fuel CO2 Emissions by Nation

Source: Fossil-Fuel CO2 Emissions by Nation

The top 5 countries (others are the United States of America, India, the Russian Federation, and Japan) account for 61.88 % of it. The world's total CO2 emissions from fossil fuels were estimated at 9.12 million thousand metric tons in 2014.

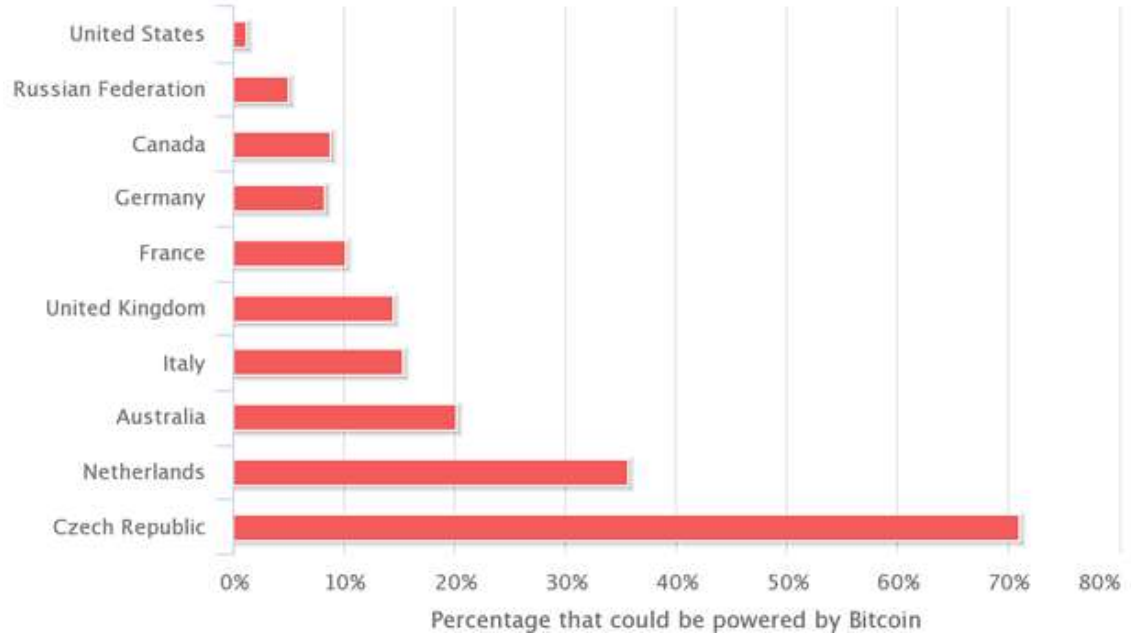

Fig. 8: Bitcoin Energy Consumption Relative to Several Countries

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Source: BitcoinEnergyConsumption.com

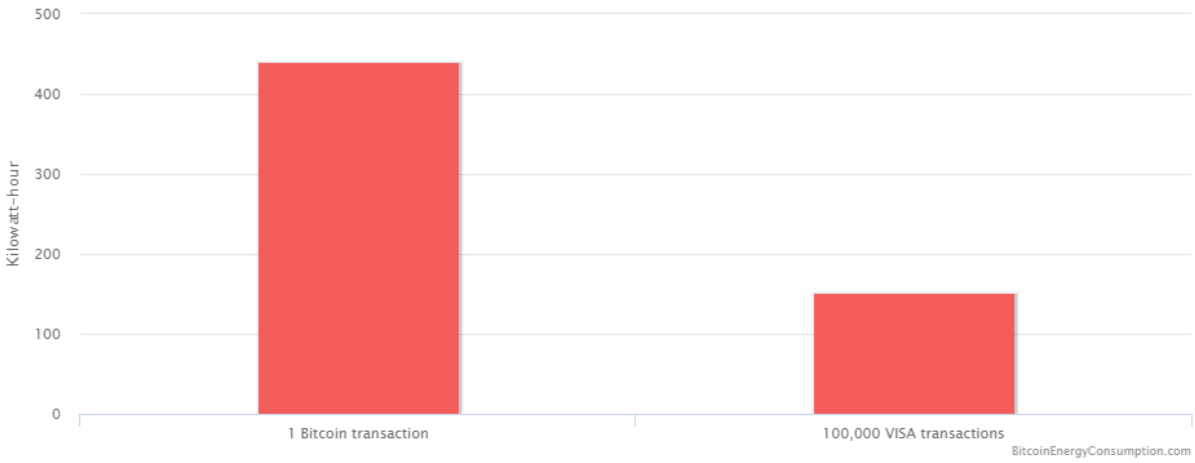

Fig. 9: Bitcoin Network versus VISA Network Average Consumption

Source: BitcoinEnergyConsumption.com

According to VISA, the company consumed a total amount of 674,922 Gigajoules of energy (from various sources) globally for all its operations. This means that VISA has an energy need equal to that of around 17,000 U.S. households. We also know VISA processed 111.2 billion transactions in 2017. With the help of these numbers, it is possible to compare both networks and show that Bitcoin is extremely more energy intensive per transaction than VISA (note that the chart below compares a single Bitcoin transaction to 100,000 VISA transactions).[7]

What are the Alternatives?

With the recent rapid growth of Cryptocurrency in general, we are speculating about what alternatives exist? Are the Cryptocurrencies that are a greener alternative to Bitcoin? The potential solutions to the environmental problem can be separated into two camps, one that deals with the way Cryptocurrency is mined and transactions are verified, and another that deals with renewable energy powered mining operations.

Green Energy Innovation Research and Development will incubate and nurture the Cryptocurrency sector by removing the need for conventional fossil fuels, and will further promote and fund the use of Green Energy and Renewables by utilizing the rapidly emerging Cryptocurrency sector to finance large scale clean energy operations. The Green Energy Innovation Research and Development aim to solve the infinite energy equation.

It is clear that the current processes are not sustainable, and they will only get worse. To put it simply, as more and more Bitcoins are mined, the mathematical problems that computers must solve to generate more Bitcoin will get increasingly difficult, requiring even more processing power as a result.

Proof of Stake (PoS)

Bitcoin's main competitor in the crypto world, Ethereum, which processes three times the number of daily

[7] https://digiconomist.net/bitcoin-energy-consumption#assumptions

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transactions like Bitcoin, is moving towards what is known as a proof of stake model. While proof of work relies on using absurd amounts of processing power to solve mathematical problems by brute force, proof of stake (PoS) relies on users "staking" their coins to verify transactions. PoS' algorithm determines which user gets to verify a transaction based off of how much each user has put at stake from their own coin wallet. The coins put at stake are lost if the user chosen user verifies an incorrect or fake transaction. PoS offers an alternative that requires nowhere near the amount of electricity or mining equipment to operate.

Nakamoto's solution involved ''time-stamping transactions by hashing them into an ongoing chain of hash-based proof-of-work.'' The proof-of-work was specifically said to involve ''scanning for a value that when hashed, such as with SHA-256, the hash begins with a number of zero bits.''[22]

Geothermal and Hydro Power

Another way to resolve the energy problem that Bitcoin presents is to power mining operations with renewable energy. Several mining operations have already been taking advantage of renewable energy in places where it is abundant and fairly inexpensive. The cloud mining operation, Genesis Mining, takes advantage of Iceland's plentiful geothermal energy near the country's capital. Another interesting approach is that of HydroMiner; a mining company set up in the mountains of Austria that harnesses geothermal energy to mine crypto. They claim that the cost of their power is 85% lower than the European average and that running their operation is carbon neutral.

Fig. 10: A Mockup of Hydro Miner's Setup

IV. Solar and Wind Power

Two other promising sources of renewable energy for mining are solar power and wind power. Some smaller more socially responsible operations such as Harvest and NastyMining have successfully used wind and solar/wind power respectively, but these mediums have yet to achieve mainstream adoption. Solar especially seems quite promising, as solar energy in states like California and Texas is incredibly cheap or even negative. Negative pricing

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occurs when a grid's generation assets can't all be switched off when solar production ramps up, as some baseload must constantly be run. At this point, solar energy producers pay consumers up to 2 cents per kilowatt-hour to use energy. Lower energy prices offer higher margins for miners (or added revenue if the price of power is negative) and the added benefit of a lower negative environmental impact.

As Bitcoin and the rest of the crypto space continue to grow, it is important that developers, miners, and users recognize the environmental implications of the technology. For Bitcoin to become mainstream, it needs to become more sustainable, whether it be through implementing a proof of stake or through incentivizing miners to switch to more sustainable power sources. Crypto has the potential to change the world, but not if it exhausts the planet's resources.[8]

V. CONCLUSION

The blockchain is the backbone of the digital currency of the world. The energy required for mining Cryptocurrencies is significant. Most of the current mining farms are using electricity from non-renewable, greenhouse gas emitting sources (coal, petroleum-based fuels, and other fossil fuels). The utilization of Blockchain technology should not be synonymous with environmental degradation and high energy costs. We need to enrich ourselves with technology innovation and creation without the detrimental effects on air and water. This is ultimately the responsibility of those creating and innovating the Cryptocurrency and Blockchain Projects. Creating a profitable solution which allows Blockchain to build a greener, more sustainable future. Using green energy and renewable powered data mining centers on a self-financing network, we have the responsibility of not just providing innovative solutions for Cryptocurrency mining, but for green and sustainable energy in all forms. Currently Green Energy and environmental sustainability sectors by investing in Green Energy real assets and incubating innovation by promoting, encouraging and financing research and development into new renewable technologies and sustainable practices to make the world is safe to live for future. It is providing a bridge between the existing regulatory environment and Blockchain ecosystems. Blockchain and Cryptocurrencies have paved the way for this generation's industrial revolution, and we must give it the best opportunity to survive if we're to pass on the baton to the millennial generation for it to thrive.

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