

Bitcoin, a gift to environment

@laurentbenichou

Acknowledgements and disclaimer

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“Bitcoin uses as much energy as Ireland!” You certainly heard this tagline that seems pretty horrifying and suggests Bitcoin is a total waste of energy and has an undefendable carbon footprint. This debate emerges from the fact that Bitcoin is using a mechanism, known as proof-of-work, that is unique in providing security and immutability to Bitcoin transactions, a key feature for a distributed payment system. The more intense the proof-of-work, the higher the security but also the more energy is spent in the network.

This article will address this debate and try to understand Bitcoin’s use of energy, and more specifically its carbon impact today and tomorrow. In this article, I will not engage in a war of figures, rather put those figures in perspective and explain the underlying trends of proof-of-work. I will also try to explain what a Bitcoin world would mean in terms of environmental but also economic sustainability. All in all, we end up discovering that Bitcoin may be much more of a hope than a threat in the sustainability debate.

This article will not participate to the current debate on the best consensus mechanism and whether proof-of-work is the best one or if it should be replaced. Others have done it better than me. And the debate will for sure continue with the ongoing shift of Ethereum from Proof-of-Work to Proof-of-Stake.



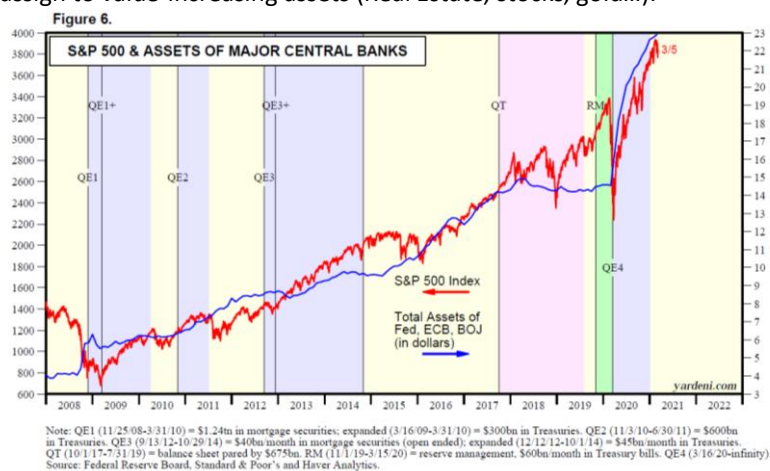
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1. Bitcoin provides valuable services to its users

Before diving into the energy efficiency debate, it is fundamental to summarize the different services Bitcoin provides to the world. They are always underestimated, specifically by the ones that declare Bitcoin as being a total waste of energy. It is also important the reader remembers Bitcoin either is the only tool to provide those features or is the tool that implements them best, therefore getting rid of Bitcoin would most of the time mean getting rid of the feature.

- a. **Bitcoin is sound money.** It is an instrument of financial freedom that can save the value of assets of billions of people from the decisions of governments or central banks. An average 2% inflation target, as commonly accepted by The US Fed¹ and the European Central Bank² can seem like a genuine and consensual governance rule but it actually makes people lose 19% of their value in 10 years or 45% in 30 years. With a 2% inflation per year, the value of your assets will be divided by 2 in one generation, notwithstanding the fact that your children will pay inheritance tax on what is remaining.

The proponents of this inflation target define inflation as “consumption price increase” and justify the 2% target mainly by i. the risk of inflation measurement tools to accurately capture the real inflation level (and the risk of deflation that they want to fight by all means) 2. The fact that a consumption basket with zero inflation indeed means that some products in the basket will be deflationary. The opponents of this 2% target policy come back to the root definition of inflation: an increase in money and credit. They assess that a sustainable 2% inflation with rocketing increase in money and credit is not credible, that high QEs can be the first phase of a hyperinflation process³ and that an arbitrarily defined consumption basket tricks citizens in suggesting the purchasing power loss is limited while some goods excluded from the basket soar in value. For example, the below chart⁴ suggests Central Banks asset increases fuel the stock market, which is kept out of official inflation measure. This would impoverish the Poores (who don’t save, let alone in stocks) and make the Riches richer, as they have capital to assign to value-increasing assets (Real Estate, stocks, gold...).



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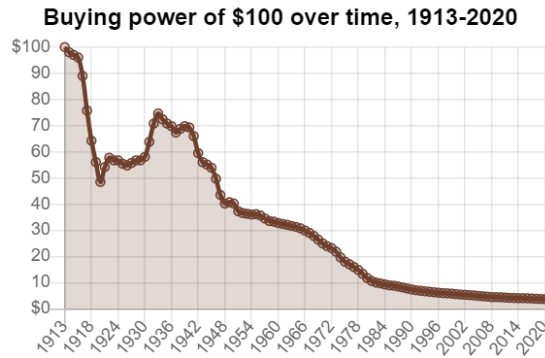
The Gold Standard protected against this until 1914, when it was abandoned. Since then, inflation that decreases the value of one unit of currency has been largely leveraged by States to finance budget deficit through the passive contribution of asset holders whose dollar-based assets conversely decreased in value over time. Unsound money is a quiet yet incredibly efficient attack on private property. It is not as visible as a tax payment but has exactly the same consequence. Asset holders try to defend their private property by storing their value in more robust assets, like gold.

¹ [The Fed - Why does the Federal Reserve aim for inflation of 2 percent over the longer run?](#)

² [ECB to consider allowing inflation to exceed target, Lagarde says | Financial Times \(ft.com\)](#)

³ <https://www.goldmoney.com/research/goldmoney-insights/an-austrian-take-on-inflation>

⁴ <https://www.yardeni.com/pub/peacockfedecbassets.pdf>



Source: <https://www.officialdata.org/us/inflation/1913?amount=100>

“The financial policy of the welfare state requires that there be no way for the owners of wealth to protect themselves. This is the shabby secret of the welfare statist’s tirades against gold. Deficit spending is simply a scheme for the confiscation of wealth. Gold stands in the way of this insidious process. It stands as a protector of property rights.”⁵ *Alan Greenspan*

Being sound money, Bitcoin is now considered a great ROI enhancement for institutional portfolios⁶ all the more as it has low correlation with other financial assets, therefore guaranteeing real portfolio diversification⁷.

b. Uncensorable money. Bitcoin is sound money because it is governed through a distributed system⁸ that is impossible to stop by States. Some even label Bitcoin as “the money of the people for the people”. Indeed, no central authority can censor it, freeze funds or prevent access to the system. Any human being can use it: Bitcoin is a bank where unbanked people can have an account, pay others and get paid. As no State has any control on the flow of transactions, there cannot be arbitrary taxes imposed on its users. That does not mean that no tax can be performed with Bitcoin, it just means that it cannot be imposed by totalitarian governments but only implemented through a broad social consensus, a method much closer to a principle of power to the people, or democracy.

The democracy goes even beyond as anyone with a Bitcoin explorer is able to audit all transactions of the system. This is not anymore a privilege of insiders like banks or the tax administration. As the Bitcoin network is fully open and auditable, the modern invocations for « transparency » and « financial inclusion » are likelier to morph into reality under a Bitcoin-based monetary system than in our legacy one.

c. Secure money. The security provided by Proof-of-work is as high as the Bitcoin’s hashrate. The higher the hashrate, the higher the cumulated power of miners, therefore the higher the cost of performing a 51% attack⁹. This hashrate, that is at the heart of the debate on Bitcoin and energy, is also the security of the system. As I am writing this article, 1hour of control of the Bitcoin blockchain costs its attacker \$700k¹⁰. This attack is even theoretical as the attacker would need hardware to control a hash rate of 114,915 PH/s, which is practically impossible.

⁵ Capitalism, the Unknown Ideal – Ayn Rand and others – quotation by Alan Greenspan, 1966

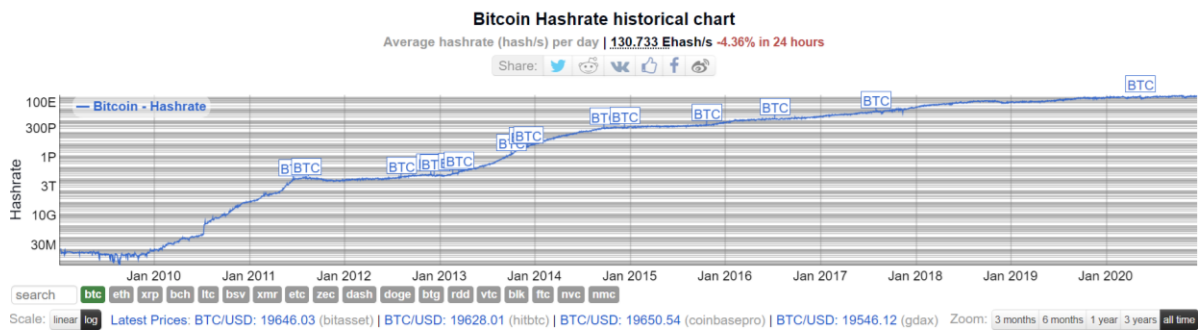
⁶ <https://static.bitwiseinvestments.com/Research/Bitwise-The-Case-For-Crypto-In-An-Institutional-Portfolio.pdf>

⁷ https://www.fidelitydigitalassets.com/bin-public/060_www_fidelity_com/documents/FDAS/Bitcoin-alternative-investment.pdf

⁸ <https://Bitcoin.org/Bitcoin.pdf>

⁹ Bitcoin 51% attack: a type of attack allowing the selective confirmation of transactions by an attacker assembling more than 50% of the Bitcoin blockchain hashrate.

¹⁰ Crypto51.app



Source: <https://bitinfocharts.com/comparison/Bitcoin-hashrate.html#log>

Even if attacked, the Bitcoin history being stored in thousands of nodes¹¹ has a distributed archive that can be the basis of a fork to get away from the attacked Bitcoin chain. That would need a bit of community governance (which is not easy in a decentralized network) but could neutralize the long-term impact of a massive attack.

Individual accounts, or wallets, are all created randomly and protected by their private keys. So far, no hack has been successful either to steal wallets or change transactions in this 12-year old “distributed database”.

With the system of block hashes and the chaining of blocks, no “fake” Bitcoin can ever be introduced in the system, which is a considerable improvement compared to the fiat system with fake banknotes constantly introduced and potential hacks on the digital systems of key stakeholders like commercial banks or clearing houses. Systems of the fiat world even have issues tracking the actual stock breakdown between stockholders at a given point in time, as was illustrated by the Dole stockholder \$2.74 claim episode of 2017¹².

d. Fast money. Anybody using the Bitcoin network will notice that transactions enter the mempool almost immediately, are confirmed within 10 minutes (if included in the 1st block) and can be considered irreversible after a few block confirmations. Whatever the amount transferred, an international remittance takes minutes instead of days in the banking system as Bitcoin is international by design. Besides, it is light money that crosses border at much lower risk and cost than gold bullions or even bank notes.

e. Cheap money. Bitcoin is not necessarily cheap if you want to transfer small amounts when the Bitcoin network is congested. Yet, it benefits from a feature that will make it very cheap to use with the right architecture: mining fees are not apportioned to the amount transacted but to the size of the Bitcoin transaction in bytes. Therefore the higher the transaction, the cheaper the fees. Bitcoin therefore incentivizes users to either group transactions or only use it as the core of a broader and cheaper “layer-2” transaction system. The irreversibility of transactions is additional financial security for online merchants that are certain to not suffer chargeback in case their customers pay with stolen debit cards.

f. Codable money. Bitcoin can be considered as a living organism which heartbeat is the confirmation of blocks every 10 minutes. This organism is also able to improve through Bitcoin Improvement Proposals. Most notable BIPs include BIP 39 that enables users to remember their private keys through a list of human-readable words, BIP 141 that introduced Segregated Witness (a method enabling to reduce the size of a transaction in a block), or BIP 340 (Schnorr signatures) / BIP 341 (Taproot) that will improve signature efficiency and increase Bitcoin’s privacy.

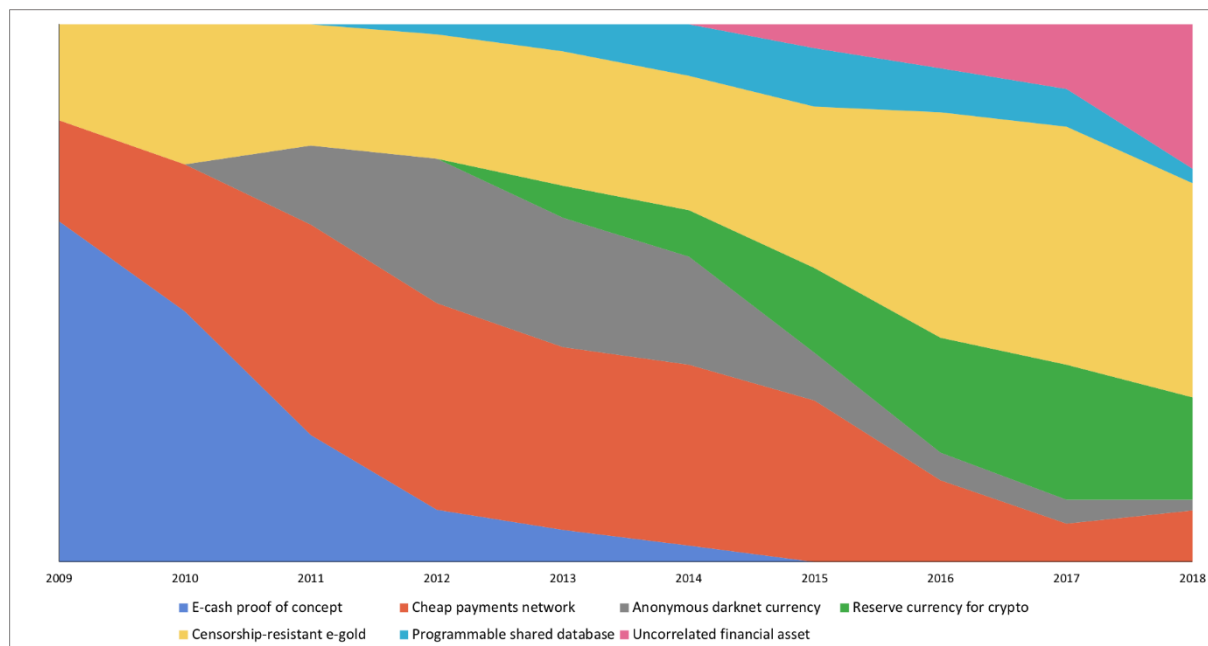
Bitcoin provides tools to enable complex transactions, like multisignatures, delayed payment or conditional payment with Pay-to-script-hash (P2SH). Those “complex” transactions may not even be considered using paper banknotes and can be difficult to implement with electronic money, as the banking system is not ready for it by design.

g. Bitcoin features we know today may only be the tip of the iceberg. Throughout the short history of Bitcoin, its investment rationale has evolved over time, as the community realizes features are differentiating

¹¹ <https://coin.dance/nodes>

¹² <https://www.bloomberg.com/opinion/articles/2017-02-17/dole-food-had-too-many-shares>

advantages over time¹³. The improvement of further BIPs may also help discover or invent new features to Bitcoin that can help its users. The number of useful features of Bitcoin will most probably be higher tomorrow than today.



Source: Bitcoin investment rationales over time

https://medium.com/@nic_carter/visions-of-Bitcoin-4b7b7cbcd24c

With this full list of advantages, the argument that Bitcoin mining is a waste of energy cannot hold without computing the overall value Bitcoin brings to the world.

Unsurprisingly, Bitcoin opponents will find Bitcoin irrelevant, therefore a waste of energy. Just like, being a man, I could consider the bra industry as being a total waste if I did not care at all about women. But in reality, if Bitcoin has a price, that means it *is* considered useful by a group of people, even though not the majority of people. And that is enough to make it a real, respectable market. Like gardening, the cinema industry or car manufacturing. The reality is that Bitcoin participants accept to pay the price of mining because they consider the advantages of Bitcoin outpace the cost of the full system (including mining). In any market, the judgment of participants is much more important than the judgment of those remaining outside of the market since the former create a fair price through offer and demand whereas the latter don't have any impact on the products' price: when you traded Panini cards at school, you knew a good shiny one could be worth more than 10 standard ones and traded cards based on such rule, even though your grandparents considered buying Panini cards was a waste of your pocket money. As a participant to the Panini card market, you just did not care about outsiders' opinion. And they had fortunately no impact. The other way around would be terrible and would turn democracy into the dictatorship of the majority.

¹³ https://medium.com/@nic__carter/visions-of-Bitcoin-4b7b7cbcd24c

2. Beyond Bitcoin, a very standard debate on fossil fuels and their impact on the environment

In reality, beyond the debate on the use of fossil fuels by Bitcoin miners in the Proof-of-Work mechanism, there are underlying debates that are more profound and not only applicable to Bitcoin. The debate on the price fossil fuel users should pay, the debate on which market players should have priority access to fossil fuels, the debate on the most socially optimal way to use (or not use) fossil fuels.

a. "It should be more expensive to use fossil fuels!"

Do fossil fuel prices capture well the long-term scarcity of fossil fuels and long-term impact of fossil fuels on global warming, decreasing life expectancy and animal extinction? History has shown that analyzing the equation in Malthus terms will inevitably lead to wrong answers as disruptive processes in the production, use or recycling of resources can completely change terms of the equation in the long-term. Extrapolation of current equation terms over a long period is a fundamental methodology flaw, if not intellectual dishonesty. And it can only lead to error. Let's take an example that will talk to everyone: the COVID predicted death toll. Under the COVID crisis, the world has accepted to live under the influence of epidemiologists, which predictive skills seem inversely apportioned to the appetite of governments to follow their opinion¹⁴: at the beginning of the crisis, they anticipated the impact of a "big flu"¹⁵. Then they envisioned a multi-million death toll¹⁶ with such a self-confidence and precision in numbers that it became politically difficult for governments to ignore their forecasts. The issue is that they were most presumably as wrong in the second period (high death toll forecast) than in the first one (low death toll forecast). Same for fossil fuel prices: a combination of Malthusian behavior with hubristic anticipation models might only lead to wrong prices. On the contrary, the current allegedly *wrong* prices justified by the good old offer vs demand rule, might not be the worst price indication of fossil fuels. There is even a possibility that they are the most accurate price attempt for fossil fuels, as they capture the anticipation of *all* market stakeholders, a miracle than no mathematical model has been able to capture so far. In this respect, it is acceptable that Bitcoin miners are able to use fossil fuels as long as they access it at market price. This supposes that no intervention is made on the price of fossil fuels, whatever the sector using them.

b. "Bitcoin steals rare energy sources from other industries"

What is the best way to prioritize the use of fossil fuels among various industries? All industries could argue that their social and economic welfare is in the highest and should then be prioritized to access fossil fuels. But this becomes a communication war in which the most dreadful consequence would be States arbitrarily dictating which sector is mostly entitled to using fossil fuels. As it is an impossible exercise, it would lead to unfair situations in most cases.

Instead, the fossil fuel price is the best tool to hierarchize industries' access to this resource: industries able to pay for the resource will have demonstrated an ability to convert the resource into a product that consumers are willing to pay for. If a company or a sector is vital to the economy, the prices of its products or services will rise, inducing an ability to pay for the fossil fuel resource needed for production. Ignoring the abilities of different industries to pay for the market price of fossil fuel would lead to partial demonstrations of the most useful economic sector. It would lead to opinions or lobbies setting the norm. Conclusion: the Bitcoin industry does not have either more or less right to use fossil fuels than any other industry and should be able to access it at the same price as other industries.

c. "Bitcoin's use of fossil fuel is not in line with a social optimum"

Is a commonly agreed optimal tradeoff between fossil fuel usage and social development reachable? While development-prone proponents will explain that maximal use of fossil fuels is indeed needed to extract billions of people out of poverty, an opposite group will seek zero-fossil fuel usage and even renounce having children to reduce their "carbon footprint responsibility". They will name and shame scape goats, regardless of their social

¹⁴ <https://twitter.com/saifedean/status/1257082952028172288>

¹⁵ <https://www.youtube.com/watch?v=H6IAOM3Ei2o>

¹⁶ <https://www.nature.com/articles/d41586-020-01003-6>

and economic impact: the steel industry in the 80's, the car industry in the 90's, the tourism industry in the 2000's, cloud servers and Bitcoin in the 2010's. As I am writing those lines, I am feverishly awaiting to know which new service I will be dictated to give up in the 2020's: police? Agriculture? Education?

Unfortunately, this debate has no end as it is impossible to set a *commonly-agreed* social optimum, as different people will value more or less any "threat to environment" of fossil fuels usage. Priority access to fossil fuels will also depend on everyone's consumption mix and ideal environment: I will give low priority access to the bra industry but my wife may not share my opinion. Besides, she can change her mind if she realizes that low priority access to fossil fuels leads to a strong increase in bras' prices.

Instead of trying to reach an impossible social optimum for energy usage, reaching an equilibrium that keeps each individual into its rights seems a better practical approach¹⁷: that would mean setting precise property rights for fossil fuels to avoid conflicts of multiple parties tapping the same source. That would also mean fossil fuel users should have to pay the full price of using those resources, meaning including the impact of this use to parties impacted by this use (e.g.: people suffering from lung disease due to emissions) i.e. a "polluter pays" principle well implemented. Conclusion: limiting the right of Bitcoin to use fossil fuels cannot be taken in the name of a social optimum, as such an optimum cannot be objectively defined. Besides, it would favor an undefined crowd (that is potentially not even human) and at the same time would trample the rights of well-identified individuals.

¹⁷ http://www.icrei.fr/en/wp-content/uploads/sites/2/2016/01/Cordato_Austrian_theory_environment.pdf

3. Bitcoin is accused of an environmental crime it has not yet committed

a. Nobody precisely knows the impact of Bitcoin on environment.

Bitcoin mining being a decentralized network, it is difficult to value the impact of mining on environment. Indeed, knowing the carbon emission of Bitcoin mining would mean we can gather information of all Bitcoin activity and all mining farm's energy mix, which is practically impossible to do. No one knows the impact of Bitcoin on environment today¹⁸. What we know is that proof-of-work is energy-intensive, and that the higher the Bitcoin price the more energy can be spent on mining. As a result, those analyzing the impact of Bitcoin on environment have to make assumptions that are more or less subject to debate, depending on their methodology. Besides, in order to forecast the impact of Bitcoin in the future, they will have to make further assumptions that may turn them into "environment epidemiologists" with the accuracy risks mentioned above¹⁹. In the past, the dot com bubble had the same kind of criticism (alleged negative impact on environment) but detailed study demonstrated that its impact on energy was far less than anticipated²⁰. The same scenario seems happening today with Bitcoin.

b. Bitcoin uses energy but may decrease energy needs of sectors it will replace.

Think about the energy consumption of the nascent car industry in a world of horse carriages. In 1899, the automobile was accused by journalist Léon-Charles Bienvenu of "annoying everyone" since it "deafens, poisons and threatens everyone, with its stunning puff!... puff!..., oil fogs and unsteady pace"²¹. Disruptive innovation usually comes from the lower market and does not seem competitive with incumbents at start²². It is therefore additional energy usage for the broad economy. But then comes the time the disruptive innovator actually competes with existing companies. The two sides of the "destructive creation" token are still in the market until the disrupted disappears from the market. Bitcoin uses energy but may result in the reduction of energy consumption of the economic activities it will replace. The only trouble we have today is to perfectly identify the activities that will be wiped out by Bitcoin (gold mining and storage? The current monetary system with central banks? cash withdrawal and financial transactions? the whole banking industry? electronic signatures? notaries?...) and when those disrupted activities will disappear (or at least reduce the amount of resources they use, due to Bitcoin competition).

c. The current estimated impact of Bitcoin on carbon emission is still very low.

Let us try to roughly assess the carbon emission of Bitcoin in the last period of 4 years when Bitcoin production offered 12.5 BTC / mined block to block miners. Assuming a profit margin of 10% for miners, a weight of electricity as high as 90% in miners' cost and a share of carbon emitting electricity in mining of 60% (all hypotheses being defensive) and an average Bitcoin price of \$10,000 over the period, we end up with a total spend of miners on fossil fuels of

$$10,000 * 210,000 / 4 * 12,5 * (1-10\%) * 90\% * 60\% = \$3.2 \text{ bn per year}$$

That is in dollar terms less than 0.1% of the world consumption of fossil fuels, estimated \$3,700bn per year²³.

¹⁸ <https://www.cnn.com/2017/12/21/no-bitcoin-is-likely-not-going-to-consume-all-the-worlds-energy-in-2020.html>

¹⁹ Jacques Favier in <https://www.youtube.com/watch?v=uZxxaeAONEk>

²⁰ Jonathan Koomey - [No, Bitcoin isn't likely to consume all the world's electricity in 2020 \(cnn.com\)](https://www.cnn.com/2017/12/21/no-bitcoin-is-likely-not-going-to-consume-all-the-worlds-energy-in-2020.html)

²¹ François Jarrige, « Écraseurs ! Les méfaits de l'automobile, documents réunis par Pierre Thiesset », *Revue d'histoire du XIXe siècle*

²² Clayton Christensen, the Innovator's dilemma

²³ <https://reneweconomy.com.au/globe-watch-us3-7-trillion-a-year-of-fossil-fuel-revenue-has-to-go-away-48016/>

4. Bitcoin is accused of an environmental crime it will most probably never commit

a. Technological misconceptions about Bitcoin lead to wrong extrapolation attempts.

The impact of Bitcoin on environment is sometimes overestimated due to the bad understanding of Bitcoin by some who wish to analyze it. The most basic traps are the analysis of hashrate to infer energy use. Indeed, the hashrate can be considered as the whole Bitcoin miner community power. Yet this power does not only come from the electricity used but also from the increasing performance of mining hardware in terms of hashrate and energy consumption. For example, the Antminer S19 Pro has an efficiency that is almost 30 times better than the Antminer S9 in TH/W²⁴. Another common pitfall is the belief that the more transactions, the more energy needed: this is a false statement as the energy used in the Bitcoin blockchain does not depend on the number of transactions processed but in the competition intensity between miners. It also explains why an energy per transaction ratio does not make real sense until the network is fully used. Using this ratio for Bitcoin today is about as representative as talking about a cost per call of a newly-built mobile communication network with only a few early adopters using it.

b. Optimization does not come first!

This seems like a pure truism but it is worth emphasizing this point raised by Bitcoin engineer nicknamed Ploum²⁵: a basic engineering rule is to first guarantee that a system works before optimizing it. And Bitcoin is still a very young technology with only 12 years of mining history. That does not mean Bitcoin founding fathers or fans are not concerned about the impact of Bitcoin.



Innovation works through improvement steps, not getting rid of suboptimal inventions

c. Bitcoin optimization is coming.

Segwit. In July 2017, the Bitcoin community activated the “Segregated Witness” protocol upgrade (or BIP 141), which multiplied by 4 the capacity of Bitcoin to confirm transactions²⁶, i.e. multiplied by 4 the energy efficiency of Bitcoin. In one protocol upgrade, Bitcoin doubled the energy efficiency gains the European steel industry took 40 years to achieve²⁷.

Layer-2. Bitcoin is now unanimously considered a technology of high (energy) cost for high provided trust. Yet all transactions don’t necessarily need a very high amount of trust and “layer 2” solutions are coming. The principle of a Layer-2 solution is to multiply transactions for a single Bitcoin network use. In Lightning Network, only two Bitcoin transactions (channel opening and channel closing) can lead to the creation of an infinity of transactions *offchain* (that is off the Bitcoin chain and within the Lightning Network).

²⁴ <https://minerstat.com/compare/antminer-s9-vs-antminer-s19>

²⁵ <https://medium.com/bitengineering/le-Bitcoin-va-t-il-de%CC%81truire-la-plan%C3%A8te-9e6908a9e96a>

²⁶ <https://academy.binance.com/en/articles/a-beginners-guide-to-segretated-witness-segwit>

²⁷ <https://setis.ec.europa.eu/technologies/energy-intensive-industries/energy-efficiency-and-co2-reduction-iron-steel-industry/info>

Another example: in a service like Woleet, the use of Merkle trees prior to Bitcoin timestamping enables the company to store millions of signatures through a single Bitcoin transaction.

d. By the way, fossil fuel optimization is also happening.

Incremental innovation. Looking at the World Coal association website, we discover scientific research enables to improve the efficiency of coal and reduce its CO2 emissions. High efficiency low emission (HELE) technologies allegedly enable to reduce coal emissions by 20%²⁸.

Disruptive innovation. Carbon capture use and storage (CCUS) in coal power plants may also change the future of coal if it manages to drastically cut CO2 emissions, potentially down to zero. The Petra Nova carbon capture facility is an example of this movement. In the aviation industry, a recent experiment could lay the foundations of a greener future for this sector: a team from Oxford University was able to transform carbon dioxide emissions into jet fuel. Scaled industrially, this process could result in “net zero” emissions from airplanes²⁹.



²⁸ <https://www.worldcoal.org/reducing-co2-emissions/high-efficiency-low-emission-coal>

²⁹ [Could Carbon Dioxide Be Turned Into Jet Fuel? | WIRED](#)

5. Bitcoin mining's energy use does not mean pollution

a. Bitcoin mining is one of the greenest energy consumers in the world

Bitcoin has its own energy mix. According to Coinshares, it is made of 73% of renewable (non-carbon emitting) sources of energy³⁰. This number is debated in the community because of the lack of actual figures from miners. Another study from Cambridge suggests that although 76% of miners use renewable energies as part of their mix, “only” 39% of hashing's total energy consumption comes from renewables³¹. Looking at studies methodologies, I tend to prefer the Coinshares study – which applies the regional energy mix to Bitcoin miners (which seems, by the way, rather conservative) – rather than the Cambridge study – which is based on a questionnaire that a minority of miners answered to. But even if we take the lower estimate, 39%, this compares with a global consumption of renewable energy of 10% worldwide³² and most probably sets Bitcoin as one of the greenest industries in the world. Bitcoin opponents like to compare it to countries, let's do it: if Bitcoin was a European country, it would be between the first (Coinshares estimate) or the fourth (Cambridge estimate) in terms of renewable energy mix. The EU average is 20% with main countries France and Germany lagging below this number³³.

b. Bitcoin should remain as green or even become greener in the future...

Importantly, Bitcoin mining is not the greenest industry in the world because miners are outspoken ecologists but because they have an economic incentive to find the cheapest electricity. This is a fundamental point of Bitcoin mining economics. And the cheapest source of energy for Bitcoin miners is most of the time not coal or fuel but hydroelectricity, all the more in places that are not well connected to energy grids and where Bitcoin miners leverage usually wasted energy, therefore can bargain it a very cheap price³⁴.

c. ...all the more if governments pass regulations to limit the use of fossil fuels

In some countries, the price of renewables is already below the price of fossil fuel energy. For example, in the United States, the levelized cost of energy is \$39/MWh for Hydro whereas around \$100/MWh for coal. In China, the average price of coal electricity was around ¥400/kwh in 2014 whereas it was ¥300/kwh for hydroelectricity³⁵. And that is without the additional bargaining power miners have with unused hydroelectricity power.

As governments pass rules to limit the use of fossil fuels and incentivize consumers to use renewable energy, the price discrepancy will increase, resulting in a lower use of fossil fuels. Green regulations can be broad or Bitcoin-specific: China has a broad objective of carbon neutrality for 2060³⁶ with the power industry being the first one to decarbonize. Specifically for Bitcoin, initiatives flourish such as the city of Ya'an's plan to use locally produced hydropower for cryptocurrency mining. A centrally-led country like China may act fast in the decarbonation of Bitcoin mining, if not the entire economy, as long as the political agenda sets this as a top priority.

Should we consider fossil fuels as being a finite source of energy, their long-term price will also increase in the long-term, making them more and more uneconomical to use.

³⁰ <https://coinshares.com/assets/resources/Research/Bitcoin-mining-network-december-2019.pdf>

³¹ <https://www.ibs.cam.ac.uk/faculty-research/centres/alternative-finance/publications/3rd-global-cryptoasset-benchmarking-study/>

³² <https://www.c2es.org/content/renewable-energy/#:~:text=Globally%2C%20renewables%20made%20up%2024,from%207%20percent%20in%202006.>

³³ https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics

³⁴ Sébastien Gouspillou in [Univers Bitcoin Podcast #13 : Minage et écologie, incompatible ? Avec Sébastien Gouspillou - YouTube](#)

³⁵ http://www.nea.gov.cn/2015-09/14/c_134621671.htm

³⁶ [China sets goal of carbon neutrality by 2060, how it will get there? - CGTN](#)

d. Bitcoin is the only industry that can accommodate without a scratch to a 100% renewable energy regulation

Assuming that all governments in the world would forbid tomorrow morning the use of fossil fuels, most economic sectors would fall in complete havoc: electricity companies would not be able to provide energy to all customers, heating would be stopped in many places of the world, airplanes would be grounded and most trucks would stop operating, which would mean restrictions of all consumer goods. Garbages could not be collected and maintenance of water, electricity and telecom networks would become extremely challenging.

Assuming Bitcoin mining has an energy mix that includes 50% of renewables (i.e. assuming it sits somewhere between the Coinshares and the Cambridge estimates), the only impact for Bitcoin would be an decrease in block frequency for a maximum of 2016 blocks i.e. around 15 days (say from 10 to 20 minutes for each confirmed block). After which the block frequency would go back to an average 10 minutes as the difficulty is automatically reset to the reduced hashing power of the Bitcoin network. If an international consensus is reached to forbid the use of fossil fuels, be it for all sectors or for Bitcoin only, Bitcoin as a system would resist it without a scratch.

e. The energy mix of Bitcoin mining is temporarily impacted by the price of Bitcoin

In any industry, a rising buying price gives oxygen to less cost-effective producers. This happens with Bitcoin when a rising price enables producers to use fossil fuels (more expensive) instead of hydropower (cheaper). One can therefore imply that in this case, the carbon impact of Bitcoin is more important. This is what happened at the end of 2020 when the sudden Bitcoin price rise triggered the opening of fossil fuel-powered Bitcoin mining sites. It is indeed a reality that a brutally rising Bitcoin price unlocks fossil fuel mining opportunities.

Even though it is a true statement, it lacks to include two factors:

1. This would only be a temporary situation as additional hydro-powered Bitcoin mining installations would be created that would increase Bitcoin's difficulty and make the more expensive players out of business. The more competition, the less margins, the less cost-inefficient players.
2. An increasing Bitcoin price means a higher appreciation by the market of the role of Bitcoin in the economy, which should translate in a higher tolerance to use natural resources for this industry.



6. Bitcoin has fundamental features that make it useful in the debate about energy

a. Bitcoin can leverage currently unharnessed energy production

Electricity networks suffer from long distances and topology, which leads to imperfect grids, energy wasted in transport and unserved enclaved locations. Bitcoin mining can be installed next to any untapped or undertapped source of energy. In Canada, Bitcoin mining enables to leverage wasted hydroelectric energy production of State-owned Hydro-Quebec³⁷. Energy bought by Bitcoin miners is energy that used to yield zero dollar in the past and that requires no additional investment from Hydro-Québec. It is therefore pure profit that clean energy producer Hydro-Quebec can then use to finance other hydroelectricity investments. Broadly speaking, Bitcoin enables to better monetize energy sources that are undertapped or wasted, i.e. the greener ones (Hydroelectricity, solar, wind).

b. Bitcoin mining can help remodel energy grids and make them greener

As Bitcoin mining has low fixed costs (core team, setup costs) and high variable costs (electricity, hardware), Bitcoin is able to provide positive ROI even in places where the Bitcoin mining activity is small. This important feature may enable to justify the creation of hydroelectric plants in rather small enclaved locations. Until now, some hydroelectric power facilities were not installed since the local energy consumption could not justify the project investment. Tomorrow, Bitcoin could support the ROI of green energy production projects, therefore remodel grids and make them greener.

c. Bitcoin mining can improve social development

If Bitcoin mining justifies the creation of new electricity production plants, it will also serve local communities lagging behind in terms of social or medical development. According to Afrobarometer, 4 in 10 Africans lack an energy connection³⁸. Bringing them fundamental utilities (such as electricity) is a necessary condition for development and may also reduce uncontrolled urbanization of African populations. The Virunga National Park in Democratic Republic of Congo provides a concrete example of how Bitcoin mining helps a population “turn to green”, as well as protect wildlife: the Virunga alliance has launched an ambitious plan of hydroelectric plants implementation in order to better protect this natural site included in the UNESCO World Heritage list. This will enable locals to gradually get rid of fossil fuel and also boost the region’s economy through cheaper electricity. Yet, it will presumably take several years before production matches demand. Bitcoin miner Sébastien Gouspillou is leading a Bitcoin mining consortium to buy excess electricity capacity for Bitcoin mining in this timeframe³⁹. In the Virunga, it happened after the creation of power plants had been decided, in an effort to improve cost-effectiveness of the project. But in the future, Bitcoin mining could be included in the financial spreadsheets before project implementation and turn projects that are not yet cost-effective into greenlighted projects.

³⁷ <https://news.Bitcoin.com/the-ceo-of-hydro-quebec-wants-to-attract-cryptocurrency-miners/>

³⁸ <https://theconversation.com/progress-in-rolling-out-of-national-power-grids-has-stalled-across-africa-128492>

³⁹ <https://www.leboncoincrypto.fr/2020/07/04/une-ferme-de-mining-dans-le-parc-national-des-virunga-rdc/blockchain/137175/>

7. Bitcoin is not only mining but potentially a more sober monetary system proposal

a. A Bitcoin-based monetary system is more sober in terms of resources usage than our current monetary system

Bitcoin does not only provide a new currency to the world but a new monetary system, sometimes referred to as the Bitcoin Standard⁴⁰, in which a lender cannot artificially create the money it loans and where there is no central bank to govern the system. This is a reminder of the Gold Standard internationally adopted between 1870's and 1914. A gold-standard system is immune against (money) inflation operated by fractional reserve banking and loose monetary policies. It will therefore keep high competition between credit seekers, therefore only provide loans or fundraising to a small fraction of credit seekers. This will prevent the spend of natural resources by projects that should not have been financed, guaranteeing a more optimal use of resources.

Economy and ecology have more in common than usually considered. Indeed, insofar that economics is concerned with the creation of the most valuable goods from the use of as few resources as possible (to maximize profit), it is nothing other than ecology. The fact that in our modern time we shall almost always differentiate the two may indicate that our current institutions hamper the proper realization of economic activities and especially economic calculation. Proponents of the Austrian School of Economics would add that at the core of this dysfunction lies the fractional system with central banks and the loose monetary policy it allows. According to them, the inflation of fiduciary media brought about by credit creation in our system sets prices from their market level and thus gives us dangerous illusions regarding the real scarcity and availability of resources. Given the current level of price distortion induced by banking and monetary institutions, we should not be surprised that economics endeavors conflict ever more often with ecological goals. In this regard, re-embracing sound money, a monetary standard which cannot be manipulated by any party, may be a critical step towards building a more sustainable future.

Indeed, it is true that when considering the desirability of a Bitcoin Standard, we should not only look at the "seen" (high energy consumption for mining) and fail to notice the "unseen" (massive reduction of uneconomical projects). In this instance, many fail to recognize that Bitcoin energy consumption would be a small price to pay for the thermodynamical benefits it could yield.

Energy savings of a Bitcoin Standard are even confirmed by economists criticizing Bitcoin on the principle that Bitcoin does not favor enough credit, which is supposedly a threat for an economy's growth potential. By saying this, they precisely imply that some activity would not be possible in a Bitcoin world... which would mean less natural resources consumption.

⁴⁰ The Bitcoin Standard, Saifedean Ammous

Conversely, Jesus Huerta de Soto explains⁴¹ that “artificial expansion of credit and money (...) immediately provide(s) entrepreneurs with purchasing power they use in overly ambitious investment projects”.



Unused shared bikes in a vacant lot in Xiamen, Fujian province, China, on December 13, 2017 - Source: the Atlantic⁴²

In China, in the late 2010's, providers of electric bike on-demand riding service engaged their investor funds into a market share war, producing absurd quantities of unused or underused bikes. This resulted in the bankruptcy of most companies, also hurt by municipal backlash of cities trying to regulate the service. The same kind of scenario took place in western cities with electric scooters: an initial exuberant consumption of resources (permitted by venture capital money) to reach market share sooner than competitors has led to a complete waste of resources, further fueled when public authorities decided to provide licenses to a select group of companies. In Paris, that concretely meant that Bird stopped operating its 4,900 scooters to make room for Tier (500 scooters in Paris at the time)⁴³. Where are those 4,900 scooters now?

⁴¹ [Money, Bank Credit, and Economic Cycles \(mises.org\)](https://mises.org/story/3444)

⁴² [Bike Share Oversupply in China: Huge Piles of Abandoned and Broken Bicycles - The Atlantic](https://www.theatlantic.com/technology/archive/2017/12/bike-share-oversupply-in-china/501111/)

⁴³ <https://www.numerama.com/tech/638769-les-trottinettes-bird-etaient-partout-a-paris-elles-doivent-desormais-disparaitre.html>

In a free economy that functions on a gold standard, such unproductive investment is severely limited; unjustified speculation does not rise, unchecked, until it engulfs an entire nation. In a free economy, the supply of money and credit needed to finance business ventures is determined by objective economic factors. It is the banking system that acts as the guardian of economic stability. The principles governing money supply operate to forbid large-scale unjustified investment.

Ayn Rand, Nathaniel Branden, et al.
Capitalism: The Unknown Ideal

Today's capitalism enables Central Banks to expand credit to a high (if not beyond) market need. It also enables States to interfere with the economy through lasting public deficits. Some economists go as far as labelling this system a 'corrupted' version of capitalism. It is anyway a version of capitalism that leads to a difficulty for all market players to track the right asset prices as regulations, interventionism and easy money blur the pure "offer vs demand" natural rule of price setting. This leads to inefficiencies in the use of natural resources: the post-Fukushima decision by Chancellor Angela Merkel to stop nuclear production in Germany prevented the country from a reduction of 1.4 billion tons of CO2 emissions between 2011 and 2017, corresponding to an estimated 20,600 deaths that could have been prevented⁴⁴.

b. Bitcoin would not protect zombie companies and their suboptimal use of resources

In a Bitcoin-centric monetary system, no central bank can take any decision on the pace of money issuance or the level of interest rates. Those rates would be defined by offer vs demand. That means that when the number of loan requests increases a lot, there would be a natural movement of lenders towards higher interest rates and more scrutiny on who is willing to borrow. That would lead to a temporary contraction of activity but that would have the advantage of redirecting investments to where the economy needs them. The contraction would be due to the ineluctable demise of some companies or sectors of the economy, but only to make the whole economy stronger in the long-term. The current habit of "bailing-out" corporations at any cost, impedes a desirable reallocation of capital toward sound economic projects. While the moral hazard that come with such systematic "bail-out" policy are often (and rightfully) discussed, the resource waste it induces is however rarely mentioned in public debates: in economics as in biological development, spending resources to maintain "zombified"/dead part of a system, such as maintaining dead body cells or sustaining dead trees in a forest, only slows down growth, diverts needed resources and does very little to enhance the real vitality of the system. All complex adaptative systems dynamically evolve through processes of internal reorganization which imply destroying subparts of the system in order to build new ones from the subcomponents thus made available. This is the "Creative destruction" of Schumpeter. And economic structures are not immune to this rule: bankruptcies are a necessary condition for growth.

The problem is that what is good for the long-term state of the economy is not necessarily considered acceptable politically in the short-term: if a political power is involved in the above natural process, it will be tempted to

⁴⁴ <https://blogs.ei.columbia.edu/2019/06/17/post-fukushima-energy-japan-germany/>

trick events to fight the short-term recession. A government can grant subsidies to falling economic sectors, a central bank can lower interest rates to save States or companies in debt. This is what is happening today with interest rates close to zero and measures of qualitative and quantitative easing decided by central banks. This helps companies that would (should?) have died in a free monetary system to remain in business, the so-called 'zombie companies', companies remaining alive in spite of low productivity, i.e. a higher users of resources than other companies: people, money... and natural resources.

Those zombie companies may survive but their poor profitability prevents them from aggressively stepping into the future. This is a cause for natural resources waste in many cases: imagine a haulage zombie company of 10 trucks. A lack of profitability will cause the zombie company to increase its trucks' life expectancy, which will cause "overusage" of fossil fuels, compared to younger and more modern trucks. In spite of lower OPEX, its competitor using hybrid electric trucks is not able to thrive as deserved due to the market share held by the zombie company. Ultimately, in the case of big zombie companies against small disruptors, it can lead to the preservation of the zombie and demise of a company that seems more adapted to the new world... and consuming less fossil fuels.

And by the way, what are coal-powered bitcoin miners if not zombie companies that should have been put out of the system by hydro-powered miners? The problem here again is an artificially low interest rate (that enables such projects to get funding), too much capital available (meaning suboptimal projects also get funding) and a wrong coal price in certain countries or regions (due to subsidies or price control).

*"Bitcoin is a new monetary system; an open, global, public, and borderless monetary system. It doesn't happen often that we get to witness a monetary system transformation."*⁴⁵

Jurica Bulovic, director of Bitcoin mining at Fidelity investments

⁴⁵ <https://t.co/WuruCJQEDx?amp=1> Citi GPS: Bitcoin at a tipping point, March 2021

8. Bitcoin reduces 'State footprint', which is crucial for our childrens' economic environment

a. A Bitcoin-based monetary system would keep States streamlined

Zero interest rates do not incentivize States to reform themselves and reduce their footprint on the rest of the economy. On the contrary, they attract more and more people and funds that should normally be used by the productive side of the economy. The very elementary truth that all capital expenditures imply opportunity cost in the form of foregone opportunities must be stressed here: any public expenditure necessarily comes at the cost of less resources for the private sector.

This is precisely what General Vauban mentions in his book *La Dixme Royale*, written for King Louis XIV at the end of the 17th Century: "It is therefore demonstrated that not only is this royal dime sufficient to provide the royal fund with adequate proceeds but could also replace other taxes that bring more damage than profit to the State and that are only good to make a few supporters richer and feed a bunch of lazy people and vagabonds that could be used elsewhere. (...) The French will work with more strength and courage when they realize that they are able to keep for themselves the main part of their profit"⁴⁶

What's more, under crises like COVID, State officials are financially able (thanks to central bank support) to take decisions that cripple the economy even more. Budget deficit finances indemnities related to administrative shop closing decisions, over-complexified vaccination processes as well as the broad economic impact of freedom restrictions (curfew, confinement...). Those decisions increase (through both the numerator and the denominator) the State debt/GDP ratio and consequently the long-term burden on taxpayers. Ultimately, excessive money issuance means a risk of asset bubbling, potentially followed by hyperinflation and bank runs.

On the contrary, a Bitcoin-based monetary system would not allow States to dedicate more resources to a situation than States finances allow. This is a market guarantee that no government is able to sacrifice tomorrow for the benefit of today. And indeed, mortgaging the resources of generations yet to come for the benefits of present voters can be interpreted as a direct violation of our democratic principles.

b. An uncensorable monetary system forces States to care about taxes' social acceptance

With the rising importance of digital payments, careless State officials may have the feeling that they can fully control the monetary system and impose surveillance throughout the whole economy. This is a social problem for the future of our societies and personal freedom: governments may think they don't need to care any longer about tax acceptance, as they have the means to impose taxes, and even automate their payments through forced haircuts directly from citizens bank accounts. Even in non-totalitarian countries, this ultimately leads to social uprisings, as experimented in France lately under the yellow-jacket movement. There is no backdoor for States in Bitcoin, therefore States have to take into account the taxpayer's point of view when issuing a new tax or increasing a tax rate: is it socially acceptable? What kind of service does the State provide in return for tax payment? Is there a largely accepted consensus for the State spend financed by the tax?...

c. An uncensorable monetary system protects the informal market from State intrusion...

Initiatives to remove cash and fight black markets have been carried out by States lately. The most striking example is the Nov-16 decision of the Indian Prime Minister to remove large bank notes from the market in order

⁴⁶ Vauban, *la Dixme royale*. Uncertified translation from original French: « Il est donc démontré que non seulement cette dixme royale est suffisante pour fournir aux fonds des tailles et des aydes, mais encore à celui de plusieurs autres impôts qui apportent bien plus de dommage à l'etat qu'ils n'y peuvent apporter de profit, et qui ne sont bons qu'à enrichir quelques partisans, et entretenir une quantité de faineans et de vagabons, qu'on pourroit occuper utilement ailleurs. (...) [les français] travailleront avec plus de force et de courage, quand ils verront que la principale partie du profit qu'ils y feront, leur demeurera. »

to fight black markets. Although it did not reach this goal (99.3% of bank notes found their way back to banks⁴⁷), the decision severely hit the informal economy, largely based on cash transactions. 1.5 million jobs were lost in the 6 months following the decision and the labor force participation rate shrank from 46.1% to 43.5%, hitting mostly young workers between 15 and 24⁴⁸. No impact was found on tax collection either.

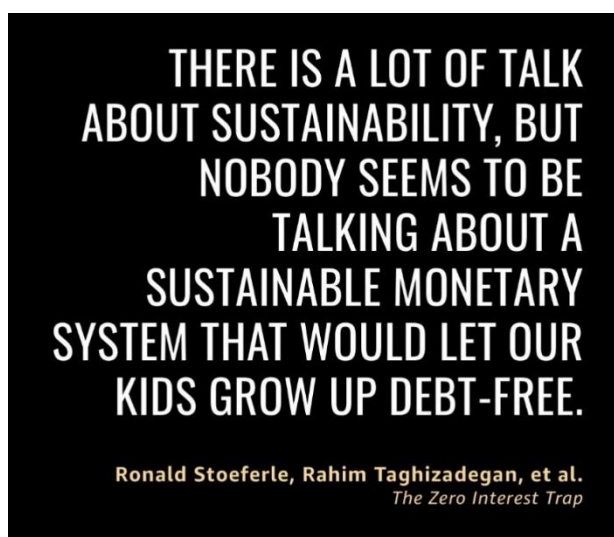
d. ... without facilitating crime or money laundering

The argument that Bitcoin facilitates crime is a dubious one as it ignores the relative opacity of the fiat system when compared to Bitcoin. As numerous cases of money-laundering and tax-evasion have demonstrated, avoiding State scrutiny by recourse to such tools as shell corporations, off-shore banking system etc... is rather easy. The FinCEN files put forward a record number of \$2tn of alleged money laundered through some respectable institutions of the traditional banking system⁴⁹. By the way, those banks may not even have been actively responsible and may just have been fooled by malicious actors that literally cash in on the technical complexity of traditional banking pipes. In order to overcome the flaws of ancient technology and systems, traditional banks need to come up with loads of compliance mechanisms and teams.

On the other hand, it may well be the case that, since all transactions are publicly recorded on the Blockchain, a Bitcoin Standard will allow for less criminal activities, as suggested by crypto journalist Grégory Raymond⁵⁰: a report by Chainalysis indeed computed that criminal activities accounted for 0.34% of cryptocurrency transactions in 2020⁵¹. This compares well with the estimate of 2-5% of global GDP laundered each year in the current banking system⁵².

e. Conclusion: Bitcoin also protects our kids' monetary environment

Bitcoin is Uncensorable value: not only does it prevent governing bodies from disrupting a free economy but it protects citizens in their property rights and personal freedom. It therefore seems like a relevant improvement proposal to our current monetary system... and a good option to save the economic environment of our children.



⁴⁷ <https://www.strategy-business.com/article/What-Happened-after-India-Eliminated-Cash?gko=1fea8>

⁴⁸ <https://www.strategy-business.com/article/What-Happened-after-India-Eliminated-Cash?gko=1fea8>

⁴⁹ https://fr.wikipedia.org/wiki/FinCEN_Files

⁵⁰ https://twitter.com/gregory_raymond/status/1351843092589137925?s=21

⁵¹ <https://blog.chainalysis.com/reports/2021-crypto-crime-report-intro-ransomware-scams-darknet-markets>

⁵² <https://www.europol.europa.eu/crime-areas-and-trends/crime-areas/economic-crime/money-laundering>