9 May 2022

Attn: Office of Science and Technology Policy (OSTP)
SENT VIA EMAIL: *DigitalAssetsRFI@ostp.eop.gov*

To whom it may concern,
Re: OSTP, Request for Information on the Climate Implications of Digital Assets

Global Digital Finance ('GDF') supports efforts by global standard setters, national authorities and regulators to consult and work with the nascent global digital / virtual asset industry. To that end, we are hereby providing input to the OSTP on the energy and climate implications of digital assets.

About GDF

GDF is a not-for-profit industry body that promotes the adoption of best practices for crypto and digital assets, and digital finance technologies through the development of conduct standards, in a shared engagement forum with market participants, policymakers, and regulators.

Established in 2018, GDF has convened a broad range of industry participants, with 300+ global community members - including some of the most influential digital asset and token companies, academics and professional services firms supporting the industry. GDF is proud to include BitMex, Coinbase, DLA Piper, EQONEX Group, EY, Gate.io, Hogan Lovells, Huobi, the London Stock Exchange Group, Ownera, R3, SDX, and Standard Chartered as patron members.

The GDF Code of Conduct (the 'Code') is an industry-led initiative driving the creation of global best practices and sound governance policies. GDF is informed by close conversations with regulators and developed through open, inclusive working groups of industry participants, legal, regulatory and compliance experts, financial services incumbents and academia. The principles set out in the Code undergo multiple stages of community peer review and open public consultation prior to ratification.

The input to this response has been curated through the work of both our ESG Woking Group. GDF is grateful for all of its members who have taken part. As always, GDF remains at your disposal for any further questions or clarifications you may have and we would welcome a meeting with you to discuss these matters in more detail with our members.

Yours faithfully,
Andrew Smith
Director of Government and Regulatory Affairs – Americas, GDF

Executive Summary of Comments

The GDF ESG working group is building on other industry initiatives to further efforts in the industry to decarbonize and understand its wider climate impact. Below we have outlined details for consideration surrounding the following key points:

1. **The USA should consider how to remain a competitive space for cryptoassets**

Unlike other industries, Bitcoin mining is relatively mobile. Previous bans in other jurisdictions have seen miners move their equipment elsewhere, taking with them the business opportunity, and sometimes moving to areas with fewer clean energy options. A ban would be at the expense of the USA remaining a competitive leader for crypto and digital asset innovation. Rather than banning cryptocurrency mining and risking that the activities move elsewhere, agencies should consider how to encourage mining firms to decarbonise using renewable energy resources.

2. **Crypto mining can support the financing of renewable energy sources**

The current global energy crisis will need to see considerable investment in renewable energy resources. Crypto mining can address some of the key challenges in the financing of renewables, such as solving load balancing requirements. Because miners can move to wherever is most convenient, mining established near renewable energy providers has been used to help balance the load and even out swings in prices.

3. **Digital assets and tokenization play a key role in climate change solutions**

Distributed ledger technology (DLT) and tokenization are being used as solutions in impact bonds, carbon credits systems, sustainably sourced supply chains, nature-based solutions, fund allocation, and more. The transparency, auditability, and accessible nature of DLT make it suitable for addressing the steep capital requirements of the climate crisis, as well as the other sustainable development goals.

4. **A robust assessment of the climate impact of crypto can be complicated to achieve**

The OSTP should work with independent academic research facilities such as the Cambridge Center of Alternative Finance to assess the full impact of the Bitcoin network and other cryptocurrencies.

5. **Industry is building initiatives to build out solutions**

This industry is agile, innovative, and energy-price sensitive. It is in the sector's interest to use technical advancements to ensure their equipment and mechanisms are as efficient as possible. Led by price and public pressure, industry initiatives are mobilizing the community to decarbonize, including public pledges, the development of best practices for science-based pathways, and industry-wide procurement of renewables.

GLOBAL DIGITAL FINANCE

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Digital Assets as part of the solution

The GDF ESG working group is aware of and focused on the industry's need to develop an impactful sustainability strategy. As we work towards mitigating the climate crisis, all industries globally will need to make compromises on energy uses.

That said, we are also aware that the public perception of crypto means that it starts on the back-foot. Many industries will be discussing their bare minimum requirements for energy use along with a broad understanding of their relative social utility. By contrast, cryptoassets' full potential and uses are not widely understood, making the energy consumption of the networks appear frivolous.

While many do not see the complete value of cryptocurrencies, the innovation in this space has produced key tools, particularly for sustainable finance. The GDF ESG report (2021) examines how DLT is being used to deliver sustainable infrastructure for a low-carbon future.

Before addressing the assessment of crypto's carbon footprint, we will first outline how cryptoassets are beneficial to addressing climate change mitigation and the broader sustainability goals.

How asset tokenization advances climate initiatives

Asset tokenization is a process whereby a typically illiquid asset is converted into digital assets – DLT-based tokens which encompasses the rules of its transfer. This can have a fractional value of the original asset, issued with rights in respect of that asset.

These tokens can address many of the issues with green and sustainability-linked investments. Compared to traditional ownership methods, asset tokenization provides a much more stringent, direct way to integrate environmental performance targets and reporting into assets, supporting the monitoring, reporting, and verification (MRV) aspects of climate-related projects.

Instead of borrowing a secured loan, a fractionalized asset token can be issued to provide rights to periodic payments arising from the income generated by that asset. This interest would vary in amount based on certain data inputs, the right to a redemption sum at a future date (i.e. capital repayment), and the right to take control of the asset, including for purposes of liquidation, if certain covenants have been breached.

Tokenization differentiates from existing standard arrangements in the area of data input, monitoring, and reporting on all aspects of the funding. Smart contracts incorporated into tokens can accommodate automated actions on the back of oracle and manual data inputs. Data inputs on science-based pathways and targets, combined with real-time evidence obtained through oracles, from carbon emission monitors, accountant recording systems, public registries and more, can automatically be linked to the token.

For example, STACS's solution includes a smart contract platform for KPI-linked bonds, and recently completed a proof of concept alongside Deutsche Bank, UBS, and Malaysia National Stock Exchange Bursa Malaysia.

Tokenization enables democratized, accessible marketplaces by creating 24/7 trading, fractional ownership, and removing post-trade friction points. The level of funding needed to address the developing climate crisis will require new avenues for funding. The digital financial industry can play a crucial role in supporting the growth of sustainable finance by reducing barriers to entry and injecting pace into an asset class that must scale quickly to meet public and climate needs.

Nature-based solutions

What is holding back sustainable development is not necessarily a lack of funding itself, but rather information asymmetries to track supply and demand, and the ability to use finance for nature-based solutions. Unlike direct greenhouse gas mitigation projects, such as renewable energy projects where tracking project impacts is relatively straightforward, there is still an acute shortage of data to demonstrate the degree to which nature-based projects are bankable.

Some providers are using DLT for reforestation. Currently, there is no standardized method for verifying crucial information about the trees in reforestation campaigns. Data blanks proliferate around even basic information such as which species of tree has been planted, where and by whom. Even rarer is the confirmation that the trees planted grow beyond seeds; that they are not prematurely lost to logging or disease; and that the carbon sequestered is of a meaningful amount.

Live example of nature-based solutions using tokenization

Veritree, a solution provider for the verification of global environmental restoration projects uses the Cardano blockchain as part of its technology stack. It launched in later 2021 with an Initial Tree Offering pilot to raise funding for 1 million trees, where users donated a token in exchange for the utility token of the project, "NFTrees", which will be redeemable for Tree Planting Certificate NFTs once the provider plants the trees. The NFTrees allow donors access to this repository and the ability to track their trees over their life cycle, observing where and when they were planted, and viewing attributes such as height, size, amount of carbon sequestered, and impact created. This campaign was successfully completed after three months, and since the beginning of 2022, Veritree has planted 10 million trees that are verifiable through its MRV system which combines human and IoT-based data collection together with blockchain technology.

Sustainability beyond climate initiatives

Various industry players are using tokenization to make investment in emerging markets more accessible. Stobox, for example, is using tokenization as a tool for funding SMEs in sub-saharan Africa, an area that both desperately needs strong investment, and yet has remained inaccessible due to the lack of legacy financial infrastructure. Investors anywhere in the world can access the digital platform to invest in the SME of their choice. Tokens are easily tradeable, meaning investors don't have to wait 20 years for the maturity of bonds – they can simply sell them on a secondary market. As investors don't have to wait for companies to go public, the overall risk is reduced, making the investment more attractive.

Mining and the growth of renewable energy resources

As explored below, it is difficult to assess the extent to which renewable energy is currently used for mining crypto. That being said, it is important to consider how crypto mining can change the financing of renewable energy production.

Crypto miners are able to move and set up new facilities around the world, including in remote areas. They are therefore well suited to use stranded energy assets where other industries have not been able to. Because they can place themselves geographically close to the energy production, the transmission loss is minimized.

One of the challenges with renewable power sources is that many do not generate power as a baseload. Production is intermittent, and they may not be able to supply the minimum amount of power needed to meet demand on an electrical grid at any given time.

The flexibility of mining makes it ideal for renewable energy suppliers. Whether supply is outpacing or lagging behind demand, mining can adjust to help balance the load and even out swings in prices.

This is already being carried out by mining firms in Texas, but could be applied in remote areas and emerging markets, where funding for energy resources is needed. Across the USA, grids in the Mid-Atlantic, New York, and California have robust demand response programs and payments for load shifting. This could be leveraged as a key incentive to attract miners to support renewable integration.

Investment opportunities

While crucial to ensure that mining firms are doing all that they can to decarbonize, it is important that the USA remain a competitive space for cryptocurrencies. The recent ban in China shows us that miners will simply move their equipment, and their profits, to another jurisdiction.

Since China moved to ban cryptocurrencies in 2021, miners have moved their equipment out of the country. According to Foundry, a crypto asset service provider, many of these miners have moved to North America. Foundry helped many of these miners with the logistics of moving the equipment to the USA.

The Foundry network mines an average of 163 bitcoins per day. Based on bitcoin's recent price of around $40,000, this translates to a daily average of $6.3 million in earnings.[1] This is money that American investors are able to reap the rewards of.

It should be noted that the move to North America and Canada is largely positive both in terms of transparency and in the uptake of renewables. However, a significant number of miners also relocated to Kazakhstan and Russia, both of which have relatively dirty grids. One recommendation would be to ensure that miners are incentivised to move to areas with access to renewable energy.

[1] https://decrypt.co/90671/bitcoin-mining-renewable-energy-foundry

Efforts to mitigate the crypto industry's climate impact

Understanding Bitcoin's energy footprint

The Cambridge Centre of Alternative Finance (CCAF) have done some of the most extensive research to date on the energy intensity of the Bitcoin network. CCAF highlights the challenges to creating a robust assessment of the Bitcoin network's carbon footprint.

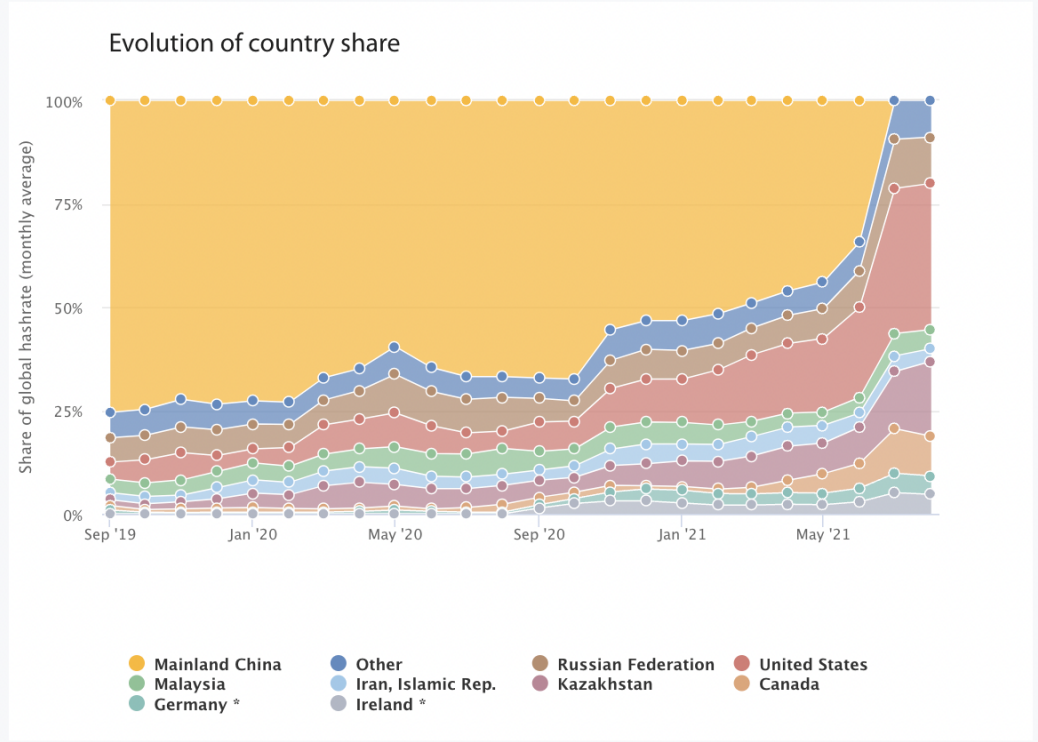
First, one must assess the electricity consumption and demands of the network. CCAF has developed a methodology for doing so, creating the Cambridge Bitcoin Electricity Consumption Index (CBECI) Even here, some trade offs have been made in the research (see: Limitations of the model).

At the time of writing, the estimated total yearly electricity consumption of Bitcoin is 144.30 TWh. The theoretical lower bound puts it at 54.07 TWh, and the upper bound puts it at 362.33 TWh. Overall, CCAF estimates that Bitcoin makes up 0.65% of the global electricity consumption, and 0.32% of energy consumption.

While this is no mean feat, it is not the energy disaster that is often portrayed in the press. Furthermore, the carbon intensity of this electricity consumption will depend on miners' use of renewable energy.

Mapping use of renewable energy resources

The location of miners can help determine whether the energy consumption is carbon intensive or not depending on the local resources and prices. The CCAF have developed a methodology for estimating the use of renewable energy creating unique longitudinal datasets on regional miner distribution spanning September 2019 to April 2021.



The CBECI research shows the seasonal migration of miners in 2019. These migrations, between hydro-rich Sichuan during the monsoon season and coal-rich Xinjiang during the dry season, materially affected the energy profile of Bitcoin mining in China. Since the data also revealed that China was responsible for two thirds of total Bitcoin hashrate up until Q3 2020, the migration had a substantial impact on global Bitcoin emissions throughout the year. With the recent exodus from China following the government crackdown on mining, miners are spreading further across the globe – making it more difficult to track them in the future.

These findings imply that the price of energy is one of the main drivers behind the changes in energy resources. Just as with other sectors, when renewable energy is cheaper than carbon, miners are unlikely to opt for carbon-intensive resources. The cost of electricity in the local area is important because miners will run their equipment as long as it remains economically profitable in electricity terms.

Other industry initiatives have formed to map the use of renewable energy sources among mining firms. The Bitcoin Mining Council relies on voluntary survey data, and according to their

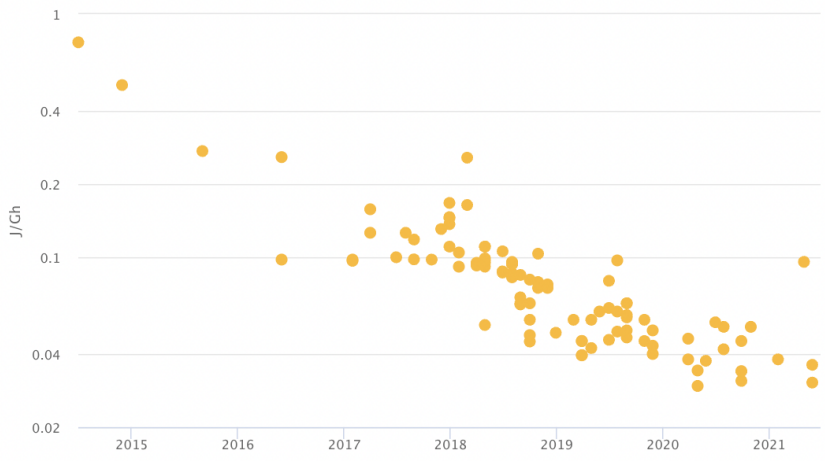
statements, they have collected information from 46% of the mining industry.[2] From this they were able to conclude that the participants were using a 66.1% sustainable electricity mix.

Mining hardware:

Understanding the energy efficiency of proof-of-work equipment is crucial to the assessment of crypto's carbon footprint. Pre 2012, mining was mostly performed using general-purpose graphics processing units (GPUs) and field-programmable gate arrays (FPGAs). In 2012 the first application-specific integrated circuits (ASICs) emerged. ASICs are specialized hardware specifically optimized for digital asset mining that are much more efficient than previous devices used for mining. As a result, ASICs dominate and are displacing GPU and FPGA mining. Generally, each ASIC miner is constructed to mine a specific digital currency.

The CCAF has compiled a list of nearly 100 different Bitcoin ASIC models designed for SHA-256 operations that have been brought to market since 2013. Mining efficiency of each machine type is expressed in Joules per Gigahash (J/Gh).[3] Given that real power usage can vary significantly depending on several parameters (e.g. usage conditions, overclocking), the manufacturer specifications have been refined with the help of experts to reflect actual power usage more accurately. The full list is available at http://sha256.cbeci.org.

Figure 1: Evolution of Bitcoin mining equipment efficiency



[2] https://bitcoinminingcouncil.com/bitcoin-mining-council-survey-confirms-year-on-year-improvements-in-sustainable-power-mix-and-technological-efficiency/
[3] https://ccaf.io/cbeci/index/methodology

Who mines?

There are different degrees of organization around miners. Individuals are able to mine cryptocurrencies using hardware in their own home. While this was popular in the earliest days of Bitcoin, it is becoming increasingly difficult to make a profit from this as an individual. Instead, many individuals choose to mine in mining pools, in which miners form a group to pool their computational resources, strengthen their probability of mining the coin, and share the rewards.

Mining can also happen via mining firms. Many mining firms have been instrumental in organizing industry initiatives to improve crypto mining's climate credentials.

Mining Firms, members of the Bitcoin Mining Council

Argo	Blockware mining	HM Tech - LLC
Atlas	BTCM	Hut8
Atnorth	Canada Computational Unlimited	Managed Crypto Mining
US Bitcoin Corp	Celsius Network	Mawson Infrastructure
BitDeer	Compute North	Microstrategy
Bit Digital	Core Scientific	Monbanc
Bitfarms	Cowa	Poolin.com
Bit5ive	Delta Blockchain Solution	PrimeBlock
Bitfury	Frontier Mining	Riot
Bitriver	Galaxy Digital	SBI crypto
Bitquest	GEM mining	Stronghold digital mining
Blockfi	GMR	Soluna
Blockfusion	GMT	Terawulf
Blockware solutions	Hive	True North

It is estimated that 10% of miners currently control 90% of Bitcoin's mining capacity, and 0.1% of miners own 50% of the network's mining capacity.

Understanding projections of Bitcoin's energy use

Most projections of Bitcoin's future energy use are speculative at this stage, and this is an area that needs further research. With the Bitcoin halving schedule in mind, alongside the fact that 90% of miners' revenue currently comes from the block reward, there are two possibilities: if the

value of BTC remains stable, there could be a reduction in energy use. If there is a significant increase in the value of BTC, there would be an increase in energy use.

It should also be noted that we are early in the development of this technology. Already in Bitcoin's lifespan, we have seen considerable progress in the energy efficiency of Bitcoin mining equipment. Considering the pace of innovation in this space, and the financial incentive to ensure that the equipment is efficient, we can expect to see further improvements to the network.

Other Networks

Networks that run on Proof-of-Stake

Beyond the Bitcoin network, or networks that run on PoW consensus mechanisms, there are other options, such as Proof-of-Stake (PoS), that use considerably less energy by minimizing the intensity of the work that each node must do by selecting participants to create new blocks based on the amount of cryptocurrency they hold, or their 'stake' in the network. Another advantage of PoS is that it offers higher flexibility to the validator node's location. There are fewer physical constraints compared to PoW mining rigs, due to the fact that Virtual Private Servers and Baremetal servers for PoS algorithms run on are widely used.

Ethereum currently uses PoW, and aims to migrate from this to Proof of Stake (PoS). However, there are difficulties in developing a Proof-of-Stake system that adheres to Ethereum's core principles of security and decentralization.

Next generation blockchain platforms are using various types of PoS mechanisms. Cardano, for example, uses a PoS protocol called Ouroboros developed from peer-reviewed scientific research to use high assurance code. This PoS protocol offers mathematically verifiable security with the same robustness as Bitcoin but with significant gains in energy efficiency, speed, decentralization, and a fair reward mechanism for transaction validation. Polkadot's Nominated Proof of Stake (NPoS) protocol was inspired by a version of Ouroboros. Another PoS blockchain, Algorand, uses post-quantum secure Pure Proof Of Stake (PPoS) protocol.

Founding entities from many PoS blockchain projects are typically self-reporting energy consumption and carbon emission estimations with significant disclaimers, and then using them to justify financing carbon offsetting projects. However, other founding entities have held off from making any such claims until they can independently and verifiably prove their network's actual energy consumption and carbon footprint.

Existing research seeking to understand the energy consumption of PoS blockchains[4] clearly demonstrate the energy efficiency of PoS blockchains in comparison to PoW blockchains. However, more research should be completed to understand the energy efficiency differences among PoS blockchains. The studies carried out so far suffer from incomplete data, use of assumptions which do not capture the heterogeneity of the design of PoS blockchains and lack of independence from blockchain projects. The Cambridge Bitcoin Electricity Consumption Index is currently the only best-in-class and independent energy consumption source of information in the blockchain space.

While PoS networks use less energy than PoW, PoW plays a fundamental coordination role that enables the network to self-organize in the absence of human subjectivity and intervention. Bitcoin occupies an exclusive place as a global, politically-neutral settlement system that enables permissionless transfers on a synthetic commodity asset free from discretionary. While future cryptoassets may be built on another consensus mechanism, it should not be ignored that there is demand for Bitcoin.

PoW and PoS blockchains fulfill different practical purposes. Both consensus mechanisms have their own design tradeoffs and implications when looking at questions of decentralization, resilience, immutability and network governance. These nuances are sidestepped by reducing the consideration to an open-shut question of energy consumption.

While there is demand for it, a ban on proof-of-work mining would not deter its use, but rather likely only move miners to other jurisdictions. This can be seen in China's banning of crypto mining, where many miners moved their equipment to the USA.

Private Blockchains

The consensus mechanism is not the only differentiator. One can also limit the number of nodes that are used to validate a transaction by using permissioned blockchain.

Whereas public blockchains (such as those used for the Bitcoin and Ethereum networks) are open for anyone to run a validating node, private blockchains limit the number of nodes that can either validate or view that transaction. The operator has the option to run the network on a small number of nodes, controlling the amount of energy used.

[4] https://arxiv.org/abs/2109.03667
https://carbon-ratings.com/

The use cases for private and public blockchains are different. Where private blockchains may be useful for enterprise-grade solutions, they make compromises on the degrees to which the network is decentralized.

Alternative distributed ledger technologies

Bitcoin is the first stage in the technological curve. PoW does not need to be 24/7 and so there is a unique issue with Bitcoin (and currently Ethereum) which is unlikely ever to be replicated, even with new PoW consensus mechanisms.

As noted, the technological developments in this space happen at pace, and this includes developments in the uses of different consensus mechanisms, and indeed different distributed ledger technologies.

For example, although Bitcoin currently represents the majority of the network, the past year has seen a considerable increase in the use of alternative coins, particularly due to the growth of DeFi. The carbon footprint of these other networks will need further thorough evaluation.

Industry initiatives to mitigate climate harms

In the face of much public criticism, the industry has mobilized to respond with various initiatives.

One such initiative is the Crypto Climate Accord, a public commitment from around 160 companies and individuals to achieve net-zero emissions from electricity consumption associated with all of their respective crypto-related operations by 2030. The initiative has over 250 supporters.

In support of this initiative, GDF launched the ESG Working Group. The group is developing a Best Practice Framework for GDF Digital Assets businesses to adopt Net Zero Targets and Science-Based Pathways (including measurement, reporting and verification aspects). The group will look to tailor this guidance to various parts of the crypto value chain, so that there is an industry-wide move to responsible energy commitments.

The group will also develop the best practices for reporting on other ESG factors, including biodiversity and social diversity. In addition, the group will look at sector-wide renewable energy procurement.

The group comes after the delivery of the ESG Report and ESG Summit, in which industry participants displayed their commitment to immediate change and will to demonstrate how the crypto ecosystem can respond positively to community requirements.

The Bitcoin Mining Council conducts research to determine how much of the mining industry is using renewable energy. Their research is bottom up, relying on surveys and self-reporting. As a result, the research presents different conclusions to CCAF's. Nevertheless, it is an example of industry mobilization around the issue.

Climate Neutral Cardano is a group of stakepool operators seeking to render the Cardano blockchain carbon neutral. They are currently developing a methodology to independently and verifiably account for carbon emissions through grant funding dispensed by Cardano's decentralized innovation fund - Project Catalyst.

Clean Up Bitcoin is an industry initiative that calls for the code to be switched from proof-of-work to another consensus mechanism. While the initiative has a sound goal - to not change the climate - it neglects the demand for proof-of-work consensus mechanisms, and the significant complications of 'switching' the code in the Bitcoin network.