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The Energy Implications of the Future of Money

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By

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In no specific order, below are the industry leaders and experts whose time and expertise have been an invaluable contribution to this report. Their views and opinions are solely personal and do not represent the institution / organization / company they represent.

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1. Introduction

The United States (U.S.) and the global financial community are at an inflection point with the advent of digital assets. Policymakers are facing a major dilemma regarding the regulatory guardrails that must be put in place for Decentralized Finance (DeFi), Stablecoins, and Central Bank Digital Currencies (CBDCs). This study will examine these three distinct types of digital assets, while also providing a comprehensive outline of case studies pertaining to the use of digital assets (DeFi and Non-Fungible Tokens) by art auction houses.

The main goals of the paper are the following: a) to describe the current regulatory landscape of digital assets, b) to identify barriers for adoption, c) to explain energy implications, d) to design policy measures, and e) to generate data-driven predictions about the future of money and digital assets. The aforesaid analysis will include open-source data, a multidimensional meta-analysis of past academic investigations and over a dozen expert interviews of thought leaders, influencers, leading academics, and various Subject Matter Experts (SMEs) and stakeholders operating in the field. Research was collected through private Q&A sessions with leading members of the digital asset community from each of the areas examined. Firsthand accounts (key informant interviews) provided insights into if and how the industry grapples with not only the climate and energy implications of various digital products but also industry trends and the future of digital assets.

1. The DeFi section will provide an overview of the current landscape and main players in the DeFi market. We will then focus on the energy usage in the DeFi ecosystem after the "Merge" and forecast regulatory guardrails for the DeFi market in the U.S.; To predict the future trends of the DeFi, we will provide policy recommendations to address its challenges including those related to energy and finance.
2. The Stablecoin section will focus on analyzing the actual and potential energy consumption of the main players across various blockchains to forecast their energy implications. We will identify current regulatory challenges and future trends that relate to their role in the future of money.
3. The CBDC section will include an overview of energy usage and climate impact, recent technological breakthroughs, most relevant public and private stakeholders, and policy recommendations. These considerations cover the endeavors of the U.S., China, the European Union, and other major players in the geoeconomic arena.
4. The art auction case study will observe the adoption and innovation in the space using tokenization for fractionalization and authentication as a model for the finance world. Both Sotheby's and Christies are traditional art houses which function as the central banks of the art world. Their adoption and use of NFTs and digital assets serves as a testimony for the adoption of digital assets. In addition, we will delve into the dynamics of NFTs as digital art vs. digital finance and NFTs used to bridge the gap between the physical art world and the digital with payment systems and authentication methods along with energy implications of using digital assets vs. traditional methods.

2. Executive Summary

A core requirement of the Columbia University School of International and Public Affairs' (SIPA) Master in International Affairs and Master in Public Affairs program is the Capstone Workshop, a live semester-long consulting project for an external client. This report is the final work product of a team of seven SIPA students working on behalf of PriceWaterHouseCooper International Limited during the spring 2023 semester.

The Digital Assets examined in this report (Decentralized Finance, Stablecoins, Central Bank Digital Assets, and Non-fungible Tokens) promise a new and innovative chapter in the history of money. Digital assets seek to solve a broad range of problems, with benefits as broad ranging as increasing financial inclusion, speeding cross-border transfers, and securing value for artists. Most simply put by Yaya J. Fanusie, Former CIA, CNAS Senior Fellow, "Technology is allowing us to present money in different ways." However, policies that address energy demands, consumer protections, and illicit activities related to digital assets will be critical to ensuring that these benefits are realized without harmful unintentional consequences. One expert interviewed for the report stated, "there is deep frustration around regulators' lack of understanding of this space". The industry experts and policy makers will need to work together to better understand the impact of each other's work on the industry and society while building expertise to enable better policy creation.

The recommendations offered here aim to provide the digital asset community with long-term clarity that allows for responsible growth.

Energy Implications

The energy implications of digital assets can be examined through two sub-issues: high energy usage or "demand", and resource type. The report finds that energy demand of digital assets is relevant only for the assets that still use Proof of Work (PoW) as the consensus mechanism, which is energy intensive by design. Depending on the region and resource mix available, digital asset mining operations that use fossil fuels contribute to climate change through the carbon dioxide emissions. The report recommends an assessment of energy sources, uses, and practices of Bitcoin miners at the federal level. The wide variety of state regulatory postures towards mining and emissions should also be taken into account. Additionally, the report recommends that 1) the practices of Bitcoin miners should be carefully evaluated to ensure that costs are not imposed back on general consumers and 2) miners are restricted from reselling energy back to the grid at a price. Regulation regarding the decommissioning of coal fired fuel plants should be proposed at the federal level. Miners should also be reporting mining activity to help understand the uses and sources of energy in their operations. In general, the recommendation is to move towards sustainable and renewable sources of energy including energy dense sources like nuclear. The report emphasizes that regulations should not impede innovation and impact the growth of technology and digital assets especially due to the value it brings in transferability of assets and the untapped potential yet to be recognized.

Decentralized Finance (DeFi) and Cryptocurrencies

The core platform of the decentralized finance market, Ethereum, has successfully reduced its energy consumption through the "Merge" in September 2022. Still, Bitcoin mining is energy intensive by design and thus faces significant energy usage issues. There has also been a surge of illicit activities in DeFi, prompting U.S. government agencies to

consider a comprehensive regulatory framework. To address this, the report recommends implementing crypto-mining regulations that consider how the Bitcoin hash rate changes with different variables. The report also recommends promoting responsible financial technology innovations that leverage blockchain technology to strengthen and advance the U.S.' position in the global financial system.

Stablecoins

U.S. regulators appear poised to regulate Stablecoins. The industry has been faced with major market failures that have attracted the attention of regulators in recent months, most notably the collapse of Terra and its Stablecoin UST. The space has since seen regulation by enforcement on Tether (UST) regarding reserves management, the order to stop issuance of BUSD (Paxos) by The New York Department of Financial Services (NYDFS), and the temporary depegging of Circle's USDC in the aftermath of Silicon Valley Bank's failure. There have been significant advances towards regulatory guardrails with the European Union's Markets in Crypto Assets (MiCA) Directive, however, the industry awaits U.S. regulations as the vast majority of market share of Stablecoins is pegged to the USD.

Regarding energy use, the report found that virtually all major Stablecoins (by volume and market share) are currently supported and transacted on Proof of Stake (PoS) enabled blockchains, which indicates minimal energy consumption by this digital asset class. As such, energy consumption is no longer a material issue in the creation of Stablecoins. Some industry leaders believe switching the consensus mechanism compromises Stablecoins' security and immutability, but overall the digital asset community believe the energy efficiency gains are a positive development for Stablecoins in general.

Through external or internal regulation, the Stablecoin industry will have to ensure the 1:1 parity that is promised to their customers, and trust will be the key factor to determine if they will play a key role in the future of money. It is still unclear which regulatory body in the US is best suited to regulate stablecoins. Ari Redbord, head of legal and government affairs at TRM Labs, explained that regulators are still looking to Congress for legal clarity which is one of the reasons we have seen a focus on enforcement actions from the Department of Treasury, the U.S. Securities and Exchange Commission (SEC), Commodities Futures Trading Commission (CFTC) and others. Redbord explained, "U.S. policy, unlike what is happening in places like Asia-Pacific, Europe, United Kingdom and Dubai, is characterized by enforcement actions. Once Congress acts, we should see less enforcement and, hopefully, an excitement from businesses about engaging in the U.S."

Central Bank Digital Currencies (CBDCs)

The energy implications of Central Bank Digital Currencies (CBDCs) depend on the design choices made in the underlying Distributed Ledger Technology (DLT) network. PoW based systems, while less energy efficient, also raise concerns around privacy, regulatory control, and suitability for CBDCs. Lessons from CBDC pilot programs, such as Project Jasper by the Central Bank of Canada, have shown that PoW protocols are not necessary for closed, private networks like wholesale payment systems. Permissioned networks that allow for stronger controls on energy consumption parameters may be more energy efficient. CBDCs can potentially contribute to reducing energy consumption and limiting

market failures in the energy market, especially when powered by renewable energy sources. CBDCs can also be used as a tool to facilitate a carbon-free economy, incentivizing low-carbon projects, reducing both private debt and the climate impact of fiat currencies, and managing risks of climate change, thereby supporting the transition to a low-carbon economy.

CBDCs will represent important components of national and international financial systems. Technology-wise, DLT has its limitations and, as a result, hybrid-DLT architectures may be utilized in order to intensively store data or process transactions. Non-PoW permissioned systems can reduce energy consumption and the overall impact on climate, while legislation should be considered early in the CBDC development process, as rollouts would require new laws. Energy efficiency and environmental impact should be considered in the entire CBDC technology stack. Moreover, cybersecurity must be a priority, with in-house task forces or professional cybersecurity firms providing expert support for implementation and risk mitigation. Furthermore, the report recommends multilateral organizations such as the World Bank, Organization for Economic Cooperation and Development (OECD), and the International Monetary Fund (IMF) to establish international standards that will foster coherent CBDC guidelines and encourage central banks to adopt significant cybersecurity measures (e.g., to avoid relying on single technology suppliers). Reliance on a single technology supplier for multi-stage processes (design, development, launch, and management of a CBDC) might lead to “data hoarding and abuse of personal data by commercial parties”¹ in the absence of specific anonymity provisions. A global framework supporting the issuance of CBDCs will be tantamount to a novel iteration of the Bretton Woods system. Namely, greater cooperation and stability would be nurtured in a rule-based environment monitored by specialized bodies.

In this context, a proper equilibrium must be achieved between data privacy and anti-money laundering and counter-terrorist financing (AML/CFT) goals. The report also advises central banks to cooperate with all stakeholders, including users, private sector intermediaries, government agencies, and political bodies. However, policymakers in most cases do not need to develop novel regulations to suit CBDCs, as existing regulatory frameworks still apply. Regarding the U.S.’s regulatory environment, Ari Redbord of TRM Labs explained that the recent U.S. Treasury Department Risk Assessment takes an activity-based approach that does not differentiate between degrees of centralization. According to Redbord the report says, “If you are engaging in financial services, you must abide by the US anti-money laundering framework (they don’t care if you are decentralized, centralized, or somewhere in between). The Treasury, on the other hand, is indicating that there is no need for new legislation or regulation, because this already falls under the Bank Secrecy Act. However, Redbord explained that the Risk Assessment, according to the Treasury, is the starting point for a discussion with the industry of DeFi regulation and guidance.

Non-Fungible Tokens (NFTs)

Old-guard art auction houses, like Sotheby’s and Christie’s, are embracing digital assets to create value. They are selling NFTs, auctioning in Ethereum, and exploring the future of blockchain technology. By doing so, they are not only staying ahead of the competition but also reducing their energy impact. Their success and continued exploration serve as

¹ BIS Innovation Hub. (June 2021). *BIS Annual Economic Report 2021*.pp. 84-85.

a critical example of how digital assets can be used responsibly and effectively in the art market, and beyond. The art auction houses' incorporation and continued exploration into digital assets has and will continue to provide a variety of benefits. Digital assets offer art auction houses business incentives by streamlining time-intensive business operations, growing their client base, and increasing revenue streams. They also present current and near future use-cases that reduce energy consumption while also securing on-chain authentication and provenance, combating illicit finance, and offsetting carbon with biodiversity tokens. Art auction houses could be considered “early adopters” in a future where the tokenization of physical objects and even experiences is popularized. However, at present NFTs are the main use case.

Additionally, digital assets can reduce art auction houses' energy impact by using Proof-of-Stake, saving on energy costs of transportation, packaging, and time, and reducing carbon footprint through system mindfulness, donations, and secondary blockchains.

3. Energy Implications

3.1. Background

The energy implications of digital assets are of interest to policymakers as they represent a novel energy demand that experienced rapid and relatively unchecked growth in the past decade. Forecasting and addressing the energy implications of digital assets will be critical to understanding its role in the U.S.'s net zero pathways. The energy demand and usage are ever increasing considering increasing population, innovation, new technologies and unforeseen future needs. Hence it is critically important that clean energy powers this demand. This section will focus on how digital assets can potentially derail the U.S.'s net zero emission goals. Bitcoin mining is currently the most energy intensive. There are opposing views on whether mining activities actually help grid load balancing, whether they make for efficient use of generated energy and whether they use sustainable and renewable forms of energy. These issues will provide a point-of-view (PoV) to understand the “future of money” as they will influence regulation, the U.S. and global time bound Bitcoins demand-supply as well as have climate implications.

The White House Office of Science and Technology Policy released a report, “Climate and Energy Implications of Crypto-Assets in the United States” after the President issued Executive Order (E.O.) 14067, Ensuring the Responsible Development of Digital Assets in March of 2022.² The report examines the challenges and opportunities the distributed ledger technologies (DLT), used extensively in blockchain technology, present to the Administration's net zero goals. Additionally, the Senate Environment and Public Works (EPW) Committee held a legislative hearing March 7, 2023 titled “Air, Climate, and Environmental Impacts of Crypto-Asset Mining: Legislative Hearing, The Crypto-Asset Environmental Transparency Act.”³ The legislation was jointly introduced by Chair Ed Markey (D-MA) and Rep. Jared Huffman (D-CA) requires crypto mining companies to report their emissions for operations that consume over 5 MW of

² White House. (September 2022). *Climate and energy Implications of Crypto-Assets in the United States Report* <https://www.whitehouse.gov/wp-content/uploads/2022/09/09-2022-Crypto-Assets-and-Climate-Report.pdf>

³ Senate Environment and Public Works Committee Hearing. (March 2023). *Air, Climate, and Environment Impacts of Crypto Mining*. <https://www.epw.senate.gov/public/index.cfm/2023/3/air-climate-and-environmental-impacts-of-crypto-asset-mining-legislative-hearing-on-s-the-crypto-asset-environmental-transparency-act-of-2023>

electricity and directs the EPA to research environmental impacts of the industry.⁴ These actions show the motivation of the Biden administration to take the climate impact of digital asset mining seriously, and their inclination to introduce regulations that align with the overall climate goals. The actual impact is still not fully understood with conflicting reports on sources of energy used and the extent of renewable and sustainable sources used in the energy consumption of mining activities.

Overall, industry members are somewhat concerned about the energy implications of the products they interface with but note that their organizations “follow the market” in the same way a car manufacturer, dealer, or rental agency might not center themselves part of the conversation surrounding emissions from vehicle travel. Sessions with individuals from the New York Federal Reserve and New York State Department of Financial Services provided insights into how digital assets pose a challenge to their mission and directives. In some instances, they provided a model for how policymakers garnered industry support for their policies that can be replicated in other states. Information gleaned from these interviews will be detailed further in each area-section below.

There is an effort within the digital asset community to address the climate impacts of these products. Most notably, the environmental advocacy non-profit, Rocky Mountain Institute partnered with Energy Web, Alliance for Innovative Regulation, and the World Economic Forum co-convened the Crypto Climate Accord, a “private sector-led initiative for the entire crypto community focused on decarbonizing the cryptocurrency and blockchain industry in record time.”⁵ The PoV on climate implications of digital assets has been mostly negative. However, increasingly, there seem to be more opportunities to advance certain net-zero energy policy and electricity load management goals using blockchain technology. There also have been breakthroughs in using more efficient ways of mining like the Proof of Stake (PoS) consensus mechanism, which Ethereum has fully transitioned to, making it 99.95% more energy efficient and increasing use of clean and renewable energy sources.⁶

3.2. Energy Use from Digital Assets

Digital asset ownership, exchange, and generation requires a substantial amount of electricity. Digiconomist found that in August 2022, global electricity usage from crypto assets was 120-240 billion kilowatt hours per year- more than the annual electricity usage of Argentina or Australia.⁷ In the U.S., which hosts roughly one third of the world’s crypto-assets, operations consume 0.9%-1.7% of total national electricity usage. This is equal to all of the electricity needed to power residential lighting in the U.S. for one year. It resulted in the same amount of greenhouse gas emissions as total freight rail transportation in the U.S.

The energy intensity of digital asset technologies is the result of the consensus mechanism used to mine and verify assets. Proof of Work (PoW) was the primary consensus mechanism for over digital assets making up 60% or more of the

⁴ Huffman. (March 2023). *Democrats Introduce Bill, set Hearing on Crypto Energy Use*. <https://huffman.house.gov/media-center/in-the-news/democrats-introduce-bill-set-hearing-on-crypto-energy-use#:~:text=The%20%22Crypto%2DAsset%20Environmental%20Transparency,investigate%20the%20industry's%20environmental%20impacts>

⁵ Crypto Climate. (March 2023). <https://cryptoclimate.org/accord/>

⁶ Cointelegraph. (October 2022). <https://cointelegraph.com/news/the-merge-brings-down-ethereum-s-network-power-consumption-by-over-99-9>

⁷ White House. (September 2022) <https://www.whitehouse.gov/wp-content/uploads/2022/09/09-2022-Crypto-Assets-and-Climate-Report.pdf>

crypto market share. However, in September 2022, Ethereum, the second largest crypto currency by volume, switched from PoW to PoS in an event referred to as “the Merge” in the digital asset community. PoS is roughly 99.95% more energy efficient than PoW, thus the merge resulted in a drastic reduction of not only Ethereum’s but the overall carbon footprint of digital assets. Bitcoin, however, still makes up the largest market volume (~40-45%), and runs on the PoW consensus mechanism, which has the largest usage of energy. Ethereum 2.0 now running PoS is the answer to already solving a big part of the energy issue.

There have been growing calls for PoW blockchains to adopt less energy-intensive consensus mechanisms. However, moving to a PoS consensus mechanism for Bitcoin is not that simple and risk-free. PoS has some potential drawbacks, such as the risk of centralization and the possibility of "nothing at stake" attacks, where validators could potentially vote for multiple competing blockchains and cause network instability. In addition, there are some technical challenges in implementing PoS in Bitcoin, such as how to ensure fair distribution of stake and prevent stake concentration among a few large holders. This is a particularly unique challenge for Bitcoin as it was the first cryptocurrency mined and constitutes the largest market capitalization with highly concentrated holders.

As stated by Alex Thorn, Head of Firmwide Research at Galaxy, “the PoS consensus mechanism is by definition oligarchical and participation in proof of stake requires holding stake already and declaring oneself to the network. By definition, this means the holders are rewarded with more holdings -- they need not compete, simply having wealth is enough to perpetuate and grow their wealth (and control of the system). Conversely, proof of work systems require no prior involvement, declaration, or holding of coins. In staking pools or exchanges, multiple stakers represent the amount held, however, the wealth concentration in PoS systems is not the real issue. In a PoS system, the platform itself maintains all control over the funds and, therefore, any governance associated with them. Said simply, centralization of staking pools presents a more dramatic and acute centralization risk than centralization of mining pools, because the former comes with additional governance rights and custodial risk to the provider while the latter carries neither.

Now, Bitcoin mining is becoming more distributed globally. According to the Cambridge University Bitcoin Electricity Consumption Index, March 21, 2023, bitcoin has an estimated 62.03 MtCO2e annualized emission rate.⁸

| | Proof of Work | Proof of Stake |
|---------------------------|---------------------------|-------------------------------------|
| Energy Usage | Significant, Real-world | Minimal, virtual |
| Finality | Strong guarantees | Medium, depends on social consensus |
| Permission-less | Completely permissionless | Requires stake & declaration |
| Consensus | Computation | Capital |
| Rollback Risk | Low, energy intensive | Medium, social consensus |
| Energy Consumption | Significant | Nominal |

Figure 1 - Comparison between PoW and PoS

⁸ Cambridge Bitcoin Electricity Consumption Index. (March 2023). <https://ccaf.io/cbeci/ghg/index>

The carbon emissions from bitcoin have not decreased since the “crypto winter,” and in fact has seen an upward trajectory since 2017. After China banned bitcoin in 2021, many crypto-firms relocated to low-energy cost regions in the U.S., seeking direct connection to power generators that are no longer profitable (often fossil fuel powered). (Some sources cite energy use as China’s motivation for the ban, but an expert interviewed for the report stated that this may not be the case as there could be other motivations). Regardless of the motivations, the ban caused Bitcoin miners to relocate to the United States. Elizabeth Moran, an environmental advocate with Earthjustice stated some miners believe that as long as Bitcoin price per coin is over \$10,000, they can still justify the cost of energy.⁹

Most major studies on the energy intensity of digital assets (Cambridge University Bitcoin Electricity Consumption Index, Digiconomist) focus on Bitcoin. Thus, the energy implications outlined in this paper of the other types of digital assets are the result estimates gleaned from open-source data.

3.3. So, has PoS helped solve the majority of the energy implications? What is the current issue?

Ariel Hudes, Head of PaceVerso opines “now there is no severe environmental impact, but the perception still exists”. However, according to Sarah Meyohas, an NFT Artist and Investor, there is a tradeoff between security and scalability and energy efficiency. Ethereum has more volume and people pay for the space, but it has a scaling issue, i.e., it is more expensive.

The current energy issue still stems from the fact that Bitcoin uses PoW mechanism which requires a high amount of energy, in some cases as much as the energy needs of a country like Argentina or Ireland. The energy intensity of Bitcoin mining is intrinsic to its design and value. It is no coincidence that the term “mining” was chosen to describe the acquisition of Bitcoin, as noted by Sarah Meyohas, an NFT artist and investor. She stated, “Bitcoin, like gold, is also mined, and there is an effort to expand this currency that exists.”

However, the real issue is in understanding the value of Bitcoin and whether the energy used towards its mining is actually worth the expenditure. Hence, the energy issue can be categorized as Usage vs. Sources.

“Energy impact and source of energy should be separated”

- John Liu, Amazon Web Services, Head of Blockchain

A distinct point-of-view on the energy implications furnished by some in the Bitcoin community, and some states with excess energy (like Nebraska¹⁰) is that energy demand is ever increasing with growing population due to increasing use of technology which in the current environment, the electric grid system is already accounting for. In a Senate Environment and Public Works Committee hearing on March 7, 2023, Senator Ricketts noted that crypto mining should

⁹ The Atlantic. (March 2023). *Crypto is Mostly Over. Its Carbon Emissions Are Not*. https://www.theatlantic.com/science/archive/2023/03/crypto-bitcoin-mining-carbon-emissions-climate-change-impact/673468/?utm_source=newsletter&utm_medium=email&utm_campaign=weekly-planet&utm_content=20230322&utm_term=The%20Weekly%20Planet

¹⁰ Nebraska Public Power District. Senate Environment and Public Works Subcommittee hearing on Crypto-asset mining and its impact on the environment. (March 2023).

not be differentiated from other data centers that store and process a huge amount of data and the dangers of potential policy discrimination, especially with the rise of AI and other technologies, should be carefully examined.

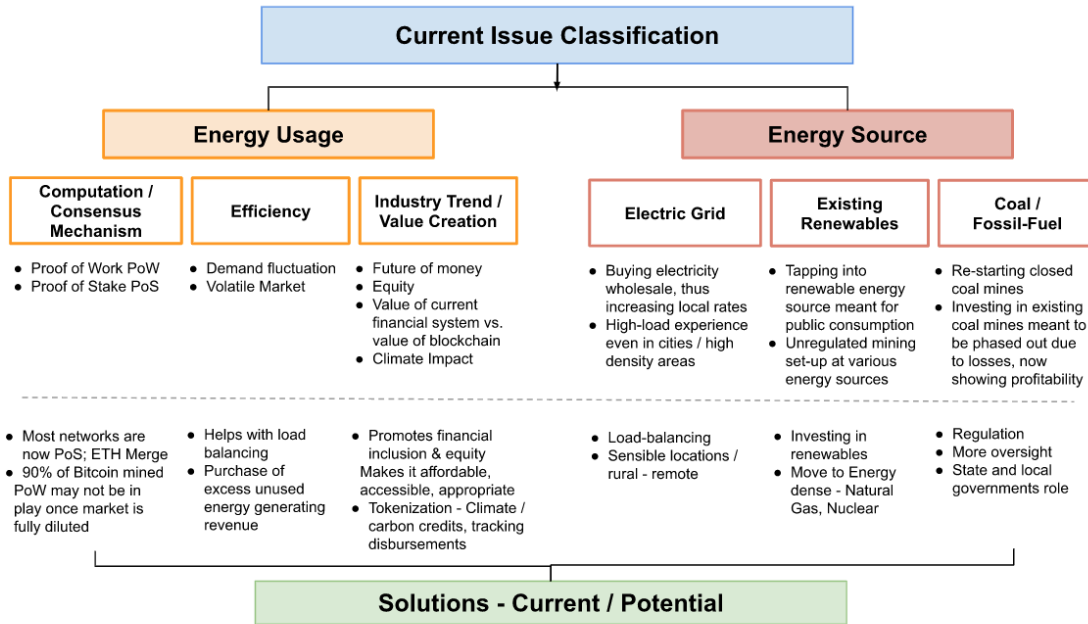


Figure 2 - Energy Uses and Sources

In terms of usage, currently, miners seek out cheaply priced electricity as buyers of last resort, which is available all around the world. Bitcoin mining is said to help the grid. The design allows for certain dynamics that are not available to other industries. Miners’ massive energy consumption combined with their ability to shut off almost instantly allows some companies to save money and make money by deftly pulling the levers of U.S. power markets. In cases where miners own generation facilities, they can avoid fees charged during peak demand, resell their electricity at a premium when prices spike and even be paid for offering to turn off. Other major energy users, like factories and hospitals, cannot reduce their power-use as routinely or dramatically without severe consequences. Bitcoin data centers consume (and pay for) vast amounts of electricity. They are Large Flexible Loads (LFL) who can turn off at a moment's notice, and are supportive during times of low and high demand. During low demand, miners consume the excess electricity available (generated) and eliminate negatively priced power, and during peak demand, miners can turn off, alleviating pressure. Bitcoin mining chops off the tails of the distribution by providing demand response during peak stress and buying energy during off-peak periods. In places like Nebraska, where excess energy produced is tough to transport but needed to ensure emergency supply, crypto mining helps load balancing and provides the state not only with additional revenue but also with job creation.

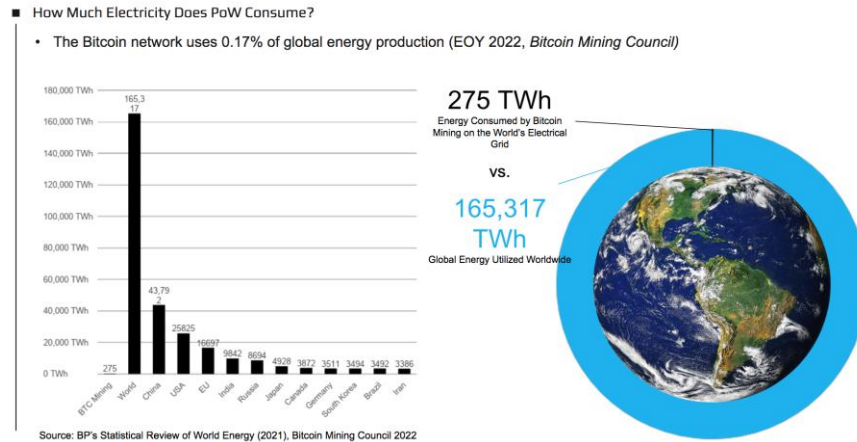


Figure 3 - Electricity Usage by PoW

However, this is not a uniformly held opinion amongst different states in the United States. Many state regulators are questioning the value of crypto mining due to the other negative externalities. In some states, notably New York, Pennsylvania and Texas, Bitcoin operators' revenue is subsidized by ratepayers. The clearest example is Texas, where Bitcoin companies are paid by the grid operator for promising to quickly power down if necessary to prevent blackouts. In practice, they rarely are asked to shut down and instead earn additional money while doing exactly what they would have been doing anyway: seeking Bitcoin. Five operations have collectively made at least \$60 million from that program since 2020, records show as per the Tech Transparency Report referenced below. In some cases, Bitcoin miners, who run collections of powerful computers that process bitcoin transactions in exchange for a financial reward, powered down their data centers, selling electricity back to the grid and collecting a bonus for doing so¹¹. In terms of job creation, according to a recent New York Times (NYT) article March 2023, Bitcoin mines bring significantly fewer jobs, and often employ only a few dozen people for the construction phase, spurring less local economic activity after completion¹². One policy expert stated that most "seek access to New York markets, it is a privilege, hence they have to comply with / strong-armed into backing the New York strategy for climate goals. However, with the type of mining happening now, it is hard to meet these [climate] goals".

Though energy usage by crypto assets, especially Bitcoin and others using PoW, is increasing, about 58.9% of Bitcoin's electricity consumption comes from renewable sources stated by 2022 Report of Bitcoin Mining Council. An article by Harvard Business Review in 2021¹³ stated a report¹⁴ which indicated that 73% of Bitcoin's energy consumption was carbon neutral, largely due to the abundance of hydropower in major mining hubs such as Southwest China and Scandinavia (pre-crypto mining ban in China). On the other hand, the Cambridge Centre for Alternative Finance (CCAF) estimated in September 2021 that the figure is closer to 39% which is a new estimate post ban. However, even if the lower

¹¹ Tech Transparency Project. (March 2023). *Cryptominers Sweetheart Deal with Texas Threatens an Already Fragile Grid*. https://techtransparencyproject.cdn.prismic.io/techtransparencyproject/369c5690-7e26-427a-9116-26f46616b45d_Crypto+Texas+Report.pdf

¹² New York Times. (April 2023). *The Real World Costs of the Digital Race for Bitcoin* <https://www.nytimes.com/2023/04/09/business/bitcoin-mining-electricity-pollution.html>

¹³ Harvard Business Review. (May 2021). *How Much Energy Does Bitcoin Actually Consume?* <https://hbr.org/2021/05/how-much-energy-does-bitcoin-actually-consume>

¹⁴ Coinshares. (April 2023). <https://coinshares.com/research/bitcoin-mining-network-december-2019>

number is correct, that’s still almost twice as much as the U.S. grid, suggesting that looking at energy consumption alone is hardly a reliable method for determining Bitcoin’s carbon emissions. A 2021 New York Times article stated that Bitcoin’s use of renewables ranged from about 40% to almost 75%.¹⁵ However, the recent NYT article in March 2023 stated above reported that coal and natural gas plants kick in to meet 85% of the demand the Bitcoin operations seem to add to their grid. This, however, takes into consideration the original supply to the grid itself.

Bitcoin is fully synthetic and can be rendered as green as its inputs. For example, gold mining can never be fully green. Bitcoin can be sustainable if miners are exclusively able to secure renewable power. Also, as carbon intensity declines with time, miners can benefit from long-term “greening of the grid”. Moving to nuclear energy will exponentially decarbonize mining.

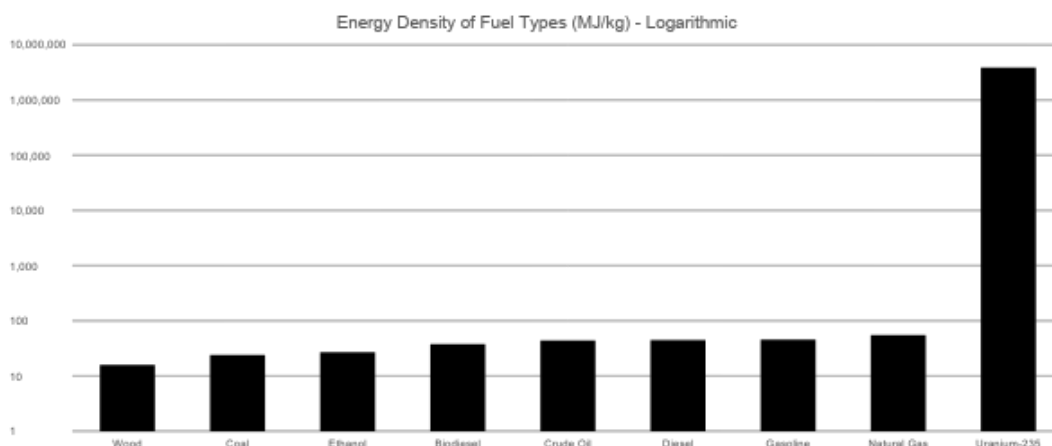


Figure 4 - Energy Density of Sources

While nuclear energy has the potential to provide a clean and reliable source of energy, the challenges associated with its use are serious; upfront capital cost, security concerns, and nuclear proliferation risk have historically made it a very controversial energy source.

The question here however is, is high energy use bad? According to Dante Disparte, Chief Strategy Officer and Head of Global Policy, Circle, carbon footprint should be criticized but technology is not neutral. “Will we ever see a scenario in the future where we evolve, our energy consumption stabilizes or reduces? If the answer is no, then the point of view on the energy consumption issue shifts in the balance favoring crypto currencies as they should not be treated any differently from other technologies or consumers of energy. However, any growing new power demand must avoid unmanageable impacts to the grid and use the most efficient technology available along with green sources of energy”.

¹⁵New York Times. (April 2023). *Bitcoin Uses More Electricity Than Some Counties- How is That Possible?*
<https://www.nytimes.com/interactive/2021/09/03/climate/bitcoin-carbon-footprint-electricity.html>

3.4. Forecast

PoW consensus mechanisms users like Bitcoin should continue to see increases (See Appendix) in energy use and greenhouse gas emissions in the next five to ten years.¹⁶ PoS consensus mechanism users will remain a negligible portion of overall energy demand in the U.S. The team expects federal regulations in both the U.S. and abroad to address the consumer protection and financial risks of digital assets. The Senate Bill 1751 would amend sections of the state’s utilities and tax code to add restrictions for crypto mining firms. However, investments from crypto mining companies, holders of digital assets and the industry will continue to advance sustainable and renewable energy production where innovation in this space can be expected.

Dante Disparte, Chief Strategy Officer and Head of Global Policy, Circle quoted “assumption is that technology is standing still but there have been breakthroughs in fusion [nuclear] energy and the Ethereum move from PoW to PoS is a big deal!”

However, some state-level regulatory action related directly to energy should be expected. The U.S. states will continue to be divided on the Senate bill and densely populated states like New York will likely follow a similar model of a two-year moratorium on new fossil fuel powered mining operations.¹⁷

3.5. Recommendations

The divide between state and federal climate goals and understanding of energy use of crypto assets needs to be addressed. An assessment of energy sources, uses and practices of Bitcoins miners should be commissioned at the federal level, where the states can then start from the same level of information and source of truth. State level considerations should be in play especially when energy production and efficiency of use varies by state level along with benefits and costs. The practices of Bitcoin miners should be carefully evaluated so that costs are not imposed back on general consumers, and miners are restricted from reselling energy back to the grid at a price (which technically should be provided for free as miners claim to use energy that is in excess). Regulation around recommissioning decommissioned coal / fossil fuel plants must be enforced at the federal level, and miners should be reporting mining activity to help understand the uses and sources of energy in their operations.

However, regulations should not impede innovation and impact the growth of technology and digital assets. The value of digital assets lies in its use for transferability and interoperability, which helps financial inclusion and potentially can help the U.S. establish dominance in this industry which it currently is lagging behind.

¹⁶ Cambridge Bitcoin Electricity Consumption Index. (March 2023). *Bitcoin greenhouse gas emission*. <https://ccaf.io/cbeci/ghg/index>

¹⁷ Politico. (January 2023). *New York Partially Banned Crypto-Mining. Now Environmentalists Want More*. <https://www.politico.com/news/2023/01/07/new-york-cryptocurrency-mining-ban-00072564#:~:text=Gov.,a%20model%20for%20other%20states>.

4. Decentralized Finance (DeFi) & Cryptocurrencies

DeFi is an innovative financial service that has the potential to serve as an alternative to traditional financial services. The development of DeFi has significant both energy and financial implications. Ethereum has successfully reduced its energy consumption through the "Merge". However, the issue of large amounts of energy usage by Bitcoin mining still persists. Moreover, as the DeFi space still lacks regulatory guardrails, there may be more enforcement action by regulatory bodies such as the Securities and Exchange Commission (SEC) and Commodity Futures Trading Commission (CFTC) due to the illicit activities happening in DeFi. In April 2023, the U.S. Department of Treasury released DeFi Illicit Finance Risk Assessment and recommended an assessment of enhancements to U.S. anti-money laundering (AML) requirements and rules for countering the financing of terrorism.

4.1. Background

4.1.1. Current Landscape of DeFi

The total value of crypto assets locked in DeFi is nearly \$51.75 billion in 2023 after the sharp drop by the LUNA crash and FTX bankruptcy in 2022 (Figure 5.1). Among the DeFi services, lending and decentralized exchange (DEX) are the most popular for crypto holders (Figure 5.2). In both DeFi platforms, crypto holders can earn higher returns with lower fees and risks. For example, lending platforms offer lenders higher yields on deposits than traditional banks. DEX can also reduce counterparty risk and systemic centralization risks in the cryptocurrency ecosystem. Although the value of the DeFi market keeps lower, DeFi will recover and continue to "coexist with centralized trading"¹⁸ since the fact remains that speedy and low-cost transactions have made DeFi attractive.

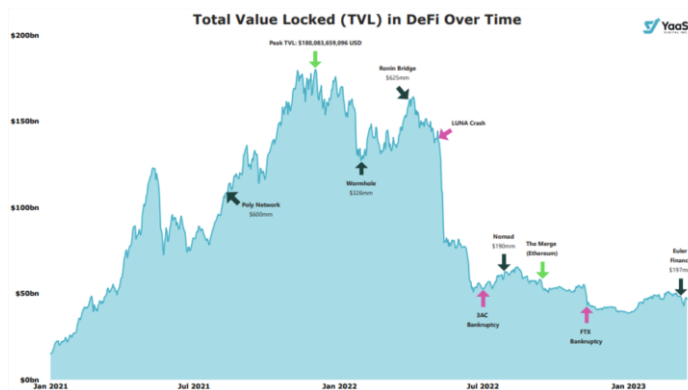


Figure 5.1 - Total Value Locked (TVL) in DeFi over Time
Source: Presentation by John D'Agostino

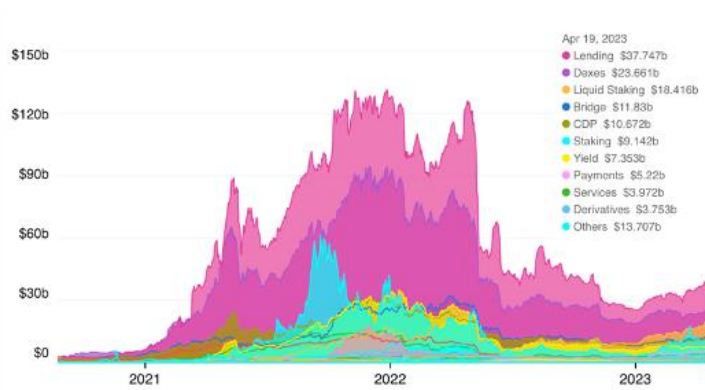


Figure 5.2 - TVL in DeFi Protocols by Contract Type
Source: DeFiLlama. <https://defillama.com/categories>.
Accessed on 19 April 2023

¹⁸ Interviewed John D' Agostino, Senior Advisor Strategy in Coinbase

4.1.2. Leading Actors

In the DeFi market, Ethereum has been a main player in the DeFi market as the majority of the DeFi ecosystem remains concentrated on its platform. However, there has been an emergence of various blockchain networks in recent years. Among these blockchain networks, Ethereum, Bitcoin, and Avalanche are expected to play a crucial role in the development of DeFi platforms.

Ethereum is a pioneer of DeFi and currently accounts for nearly 68.42% of the DeFi market¹⁹. It was one of the first blockchain networks to introduce smart contracts enabling the creation of the DeFi and NFT ecosystem. Ethereum is the blockchain network with the most developers with nearly 4,000 active developers²⁰. It has paved the way for novel financial services and instruments, including DEX, automated loan platforms, and NFTs.

Bitcoin is the largest blockchain network and has a native cryptocurrency, Bitcoin (BTC), which has the highest trading volume and capitalization in the cryptocurrency market. Although the Bitcoin network does not support smart contracts, Taproot's upgrade in November 2021 and Layer-2 solutions such as Lightning Network and Rootstock have improved scalability and efficiency, enabling the launch of Bitcoin-based DeFi platforms. While DeFi on Bitcoin is currently less approachable than on the Ethereum blockchain, it has the potential to grow in the DeFi market due to its high market capitalization.

Avalanche has shown the most rapid growth in the DeFi market compared with other blockchains having cryptocurrency except Ethereum. Avalanche's consensus protocol has high scalability, low transaction fees, and is interoperable with Ethereum, allowing DeFi applications built on Avalanche to handle high transaction volumes with fast transaction processing times.

4.2. Energy Implications

Effect of the "Merge" on Energy in DeFi

DeFi has significantly improved its sustainability after Ethereum successfully changed its consensus mechanism from PoW to PoS, known as the "Merge." Before the "Merge", Ethereum ranked second in the blockchain in terms of electricity consumption, consuming 70.4 TWh per year. However, after the "Merge", the energy consumption of Ethereum was effectively reduced by 99.95%. As Ethereum is the core platform for nearly 68.42% of the entire DeFi market, the "Merge" essentially cleared itself from the debate in cryptocurrency energy consumption.

Compared to traditional payment systems, decentralized transactions on the non-PoW blockchain consume less energy. Permissioned blockchains have central authorities that control protocols optimized for energy consumption²¹. The "Merge" has also helped maintain lower energy consumption for transactions on the Ethereum blockchain, even as more nodes are added to the network.

¹⁹ DeFiLlama. (April 2023). *Total Value Locked All Chains*. <https://defillama.com/chains>

²⁰ Horowitz, A. (2022). *State of Crypto*. a16zcrypto. https://api.a16zcrypto.com/wp-content/uploads/2022/05/state-of-crypto-2022_a16z-crypto.pdf, pp.18

²¹ IMF. (June 2022). *Fintech notes: Digital currencies and energy consumptions*. <https://www.imf.org/en/Publications/fintech-notes/Issues/2022/06/07/Digital-Currencies-and-Energy-Consumption-517866>, pp.9-10

Remaining Challenge of Energy Consumption after the "Merge"

When discussing the future of energy implications for DeFi, it is important to consider two perspectives: 1) electricity usage in mining activities and 2) energy consumption in emerging DeFi market activity. The first perspective, after the "Merge", has focused on only electricity usage for Bitcoin mining activities. However, we believe that, in the near future, the second perspective should be examined more closely as we see more applications emerging from the Web 3.0 ecosystem. Anca Bogdana Rusu, Head of Public Sector, cLabs, Celo quoted:

“Mainstream media latches on to energy consumption by blockchain. But you do not see an analysis comparison, not just of Bitcoin against a country, but what you consume and the value that you produce, which is a more balanced comparison... There are a lot of ways in which this tech [blockchain] can effectively design a financial system that internalizes more of the cost of consuming energy resources in a way that is more valuable or tangible.”

- Anca Bogdana Rusu, Head of Public Sector, cLabs, Celo

However, Bitcoin's PoW consensus mechanism is the most energy-intensive, consuming roughly 92.4 TWh to 145 TWh per year, equivalent to Argentina's annual electricity usage²².

4.3. Future Landscape of DeFi and Cryptocurrencies

4.3.1. Future of Bitcoin

With Bitcoin mining being the largest energy-consuming activity in the DeFi world after the "Merge", the future energy implications for the DeFi following such a trajectory would be greatly dependent on the future of Bitcoin.

The amount of energy used by the Bitcoin network is influenced by several factors that are interconnected and some of which respond to the changes in the price of Bitcoin: 1) **mining hardware efficiency**, notably power consumption and hashrate, 2) **network hashrate**, the combined rate at which all miners on the network are simultaneously guessing solutions to the puzzle, 3) **“difficulty” of solving the puzzle**, which is adjusted in response to the network hashrate to maintain the target block rate of one block every 10 minutes, and 4) **energy consumption cost by IT (mining) and non-IT infrastructure (cooling and lighting²³)**

The value of Bitcoin also has a crucial impact on the amount of energy used by miners, as it would not be economically rational for them to spend more on electricity than the actual value of the block reward. The amount of energy used by Bitcoin is therefore determined by the level of effort that miners are willing to put in to earn a block reward.

There has been a growing trend in the crypto-mining industry shifts towards renewable energy sources, but the Bitcoin miners have more incentive to run their equipment with large amounts of energy to earn benefits from minted Bitcoin and low mining cost. Alex Thorn, Head of Firmwide Research at Galaxy, stated:

²² Digiconomist. (March 2023). *Bitcoin energy consumption index*. <https://digiconomist.net/bitcoin-energy-consumption>

²³ IEA. (July 2019). *Bitcoin energy use: mined the gap*. <https://www.iea.org/commentaries/bitcoin-energy-use-mined-the-gap>

"[Bitcoin] is significantly more sustainable than basically every country... Bitcoin miners seek out the lowest possible cost of entry because mining margins are thin, and there's basically [three] inputs into their profitability: the efficiency of their machines, how cheap electricity is [and] the price of Bitcoin."

- Alex Thorn, Head of Firmwide Research at Galaxy

The arguments that are in favor of crypto goes beyond renewables. According to research by ACS Sustainable Chemistry & Engineering, several niche applications for crypto-mining are also gaining their weight since 2020, such as utilizing energy generated by excess gas flaring (which in most cases is just burned or released to the atmosphere), the energy released from methane generated in landfills, and ocean thermal energy conversion (OTEC). The amount of flared gas in 2020 is estimated to be equivalent to 49 GW of electricity globally. There are roughly 1250 landfills in the U.S. alone, which, if harnessed, would amount to roughly 2 GW of power. Potential power output for global OTEC implementation is estimated to be 2–7 TW, (68) on par with the global electricity consumption today²⁴.

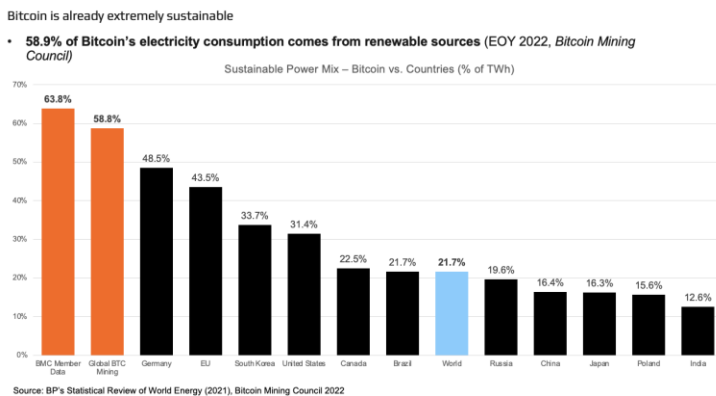


Figure 6.1 - Sustainable Power Mix of Bitcoin

Source: Presentation by Alex Thorn



Figure 6.2 - Price, Difficulty and Hashrate Index of

Source: International Energy Agency

The outlook for Bitcoin energy use, however, is still highly uncertain, hinged on efficiency improvements in hardware, bitcoin price trends, and regulatory restrictions on bitcoin mining or use in key markets.

It's worth noting that Adam Rozenchwajg, Manager Partner of Goehring & Rozenchwajg Associates, a fundamental research firm focused exclusively on contrarian natural resource investments, proposed that the rise in crypto-mining activity is a part of the greater trend of the increase in energy-intensive activities that corresponds in the decrease in energy price in the past two decades. With such a trend in mind, a potential increase in the energy cost in the coming years that is caused by the underinvestment in energy efficiency technology in the past few years and an increase in material costs would to some degree result in higher mining costs for Bitcoin.

²⁴ Velicky, M. (November 2023). *Renewable energy transition facilitated by Bitcoin*. ACS Publications. <https://pubs.acs.org/doi/10.1021/acssuschemeng.2c06077>

²⁵ IEA. (October 2022). *Bitcoin price, hashrate and difficulties indexes, 2017-2019*. <https://www.iea.org/data-and-statistics/charts/bitcoin-price-hashrate-and-difficulties-indexes-2017-2019>

“The U.S. severely underinvested in energy and energy infrastructure in the last 10-15 years, and the problem with renewables going forward makes that problem even more urgent.”

- Adam Rozenchwajg, Manager Partner of Goehring & Rozenchwajg Associates

The implication for regulation is mixed, although no authoritative research has been published to decode the energy usage for Bitcoin mining and the relationship among the dependent factors. Regulators do have the option to start tackling the sub-areas that have proven to be correlated with the mining activity. For example, they could establish a more standardized and detailed framework for miners and mining companies, or artificially manipulate the electricity price for the miners.

4.3.2. Future Regulation in DeFi

The regulatory oversight in the DeFi market is significant for enhancing the security of DeFi platforms. Since the collapse of crypto exchange FTX Ltd. in November 2022, U.S. government agencies have been seeking to regulate crypto transactions, especially staking services (Annex 1: Timeline of U.S. Regulators Charging Crypto Firms). With the Biden Administration's Executive Order for digital assets and the momentum of charging by regulators, various investment patterns such as DeFi lending, trading, and yield farming could be subjected to regulation.

However, Alex Zerden, Founder and Principal of Capitol Peak Strategies, who formerly worked in the U.S. Treasury Department stated that “Regulation of digital assets requires thinking about what is new about this space. A lot of cryptos is currently covered by the current regimes, particularly on sanctions and AML/CFT issues.” He also underscored the value of investment in regulating this space now.

“During the pandemic, up to 35 million Americans were unable to receive stimulus payments in a timely manner due in part to a lack of access to financial services.”

-Alex Zerden, Founder and Principal of Capitol Peak Strategies

Moreover, the DeFi protocol has seen significant growth in illicit funding such as money-laundering and terrorist financing. In April 2023, the U.S. Department of Treasury recommended an assessment of enhancements to the U.S. AML requirements and rules for countering the financing of terrorism as released DeFi Illicit Finance Risk Assessment. Therefore, the bureaucracies are likely to push the DeFi market into traditional financial regulatory frameworks and stress the importance of Know-Your-Customer (KYC) and AML.

4.4. Policy Recommendation

There are several cases of crypto-mining regulation and projects aimed at increasing transparency in blockchain transactions. Based on the case study and examining the future of the DeFi subsector, we recommend regulatory efforts in the following two perspectives: 1) crypto-mining regulations that factor in how hash rate changes accordingly to different variables; 2) responsible fintech innovations using blockchain technology that solidify and advance U.S.’ position in the global financial system.

Case Study 1 : Crypto-mining Regulation

Following China's crypto ban in 2021, crypto-miners relocated to countries offering cheaper electricity prices and colder climates (for low cooling cost). U.S., Kazakhstan, and Russia. Kazakhstan and Norway are examples of countries that have become popular mining hubs and have implemented regulations to address the environmental impact of mining and ensure the legal and transparent mining operations²⁶.

In Kazakhstan, under Tokayev's administration, crypto-miners must obtain a license from the Ministry of Digital Development, provide comprehensive information about their operations and undergo monitoring. In March 2022, the Financial Monitoring Agency terminated 55 illegal mining farms and 51 entities, resulting in a decrease of 600MWh in daily energy consumption²⁷. From January 2023, crypto miners in Kazakhstan are subject to taxation based on the average price of the electricity consumed for mining.

In Norway, in October 2022, the Norwegian government eliminated tax incentives for data centers and crypto-mining to promote the distribution of renewable power to the community and prevent electricity price hikes.

Regulating mining operations through licensing, monitoring, and electricity consumption taxation of mining could maintain energy use and stabilize the electricity market. In the U.S., New York has licensing regulations for mining, but permits will be restricted only to new PoW mining operations in the state that uses 100% renewable energy in 2024. On the other hand, some states with excess electricity supply like Montana and Kentucky are considering accepting more crypto-mining operations to balance the market²⁸. It is crucial to consider the specific energy circumstances of each state when determining the level of regulation for crypto-mining.

Case Study 2: Responsible Fintech Innovation

Singapore Exchange Limited (SGX)²⁹, a highly regulated investment holding company, began exploring the use of blockchain to codify rights and obligations in a consistent and coherent way to create a truly digital end-to-end marketplace. "Blockchain is a frequently misunderstood technology, yet it is also one of the most promising areas of innovation today for specific use cases that involve transactions at scale," says Peter Shen, head of technology strategy and innovation at SGX. "Smart contracts and distributed ledgers have great potential to fundamentally transform capital markets, making financial transactions and processes more transparent, resilient, and less costly."

SGX partnered with Amazon Web Services Managed Blockchain service to increase transaction transfer efficiency. Using managed blockchain, SGX no longer needs to rely on an intermediary to process and send information back and forth, which enables transaction transparency across a shared ledger. As a result, the company expects to reduce settlement time for trades by up to 60 percent.

²⁶ For a detailed background on the stablecoin industry, see Annex 1- Background related to Case-study

²⁷ Tassev, L. (2022). *Kazakhstan shuts down over 100 crypto mining farms*. Bitcoin.com. <https://news.bitcoin.com/kazakhstan-shuts-down-over-100-crypto-mining-farms/>

²⁸ For a detailed background on the stablecoin industry, see Annex 1- crypto-mining Regulation after the crypto ban in China

²⁹ For a detailed background on the stablecoin industry, see Annex 1- Background related to Case-study

Policy Proposal

Based on case study 1, it is clear that the U.S., with the world's largest hash rate, urgently needs licensing and tax policies for Bitcoin mining mainly at the state level. These measures are essential in promoting transparency in the mining industry, and preventing excessive energy consumption by Bitcoin mining, thereby maintaining stability in the electricity market in each state.

Figure 7 is a comprehensive process flow chart of crypto-mining regulation. This chart breaks down various key actors related to the crypto-mining industry and outlines corresponding regulatory measures as a guideline.

First, crypto-miners or mining firms would need to apply for permission to mine, and the state government agencies could issue licenses only after verifying their business plans and records. Second, at the federal level, additional fees could be imposed on mining equipment such as Application Specific Integrated Circuits (ASICs) and their chips. To prevent the purchase of ASICs with cheaper and less energy efficiency, energy performance standards could be established for the sale of ASICs. In addition, ASIC sellers, including miners reselling their ASICs, could be required to register for selling equipment by state government agencies.

Third, the federal government could impose additional taxes based on electricity consumption for mining as proposed by the U.S. Department of Treasury in March 2023 (a 30% excise tax on the cost of electricity used in digital asset mining). Fourth, the state government agencies could adjust the rate of fees for the sale of ASICs and taxes regularly (quarterly or yearly) based on the circumstance of the crypto and electricity market and other economic factors. Finally, miners could be required to report their mining records, and state government agencies could monitor their mining activities and energy consumption.

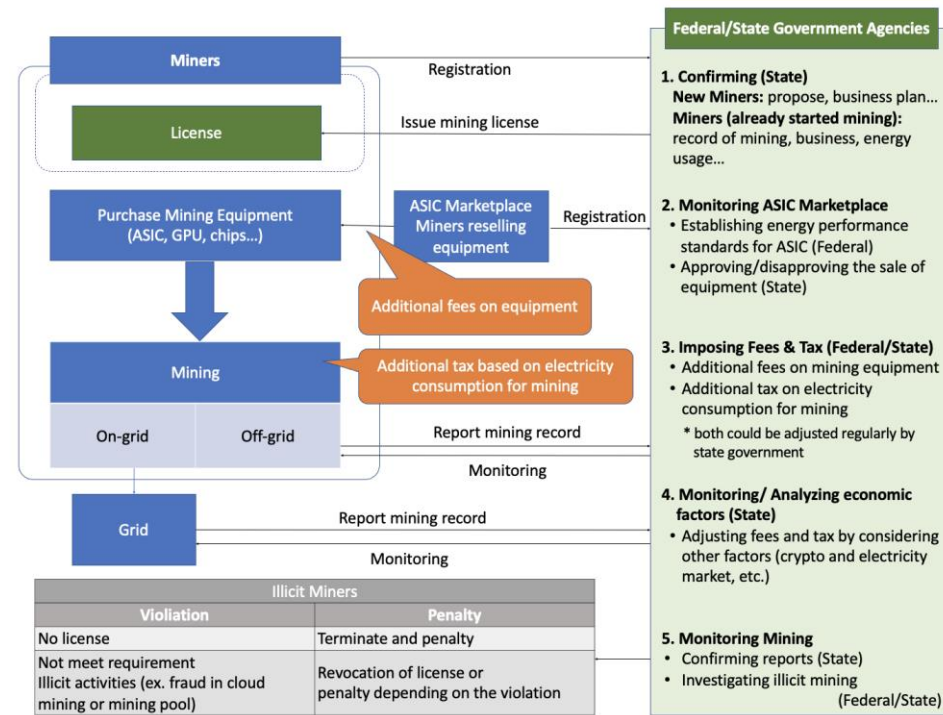


Figure 7 - Flow Chart of Crypto-mining Regulation

The state government could also investigate illicit mining and impose strict penalties for violations. In the event of major cases and securities violations, for example, federal government agencies such as the SEC could be involved in investigations.

4.5. Conclusion

As the Defi market is expected to recover in the future, addressing the challenge of the pseudonymous environment in blockchain transactions, including in DeFi, has become increasingly important. To better protect participants, improving disclosure in DeFi applications could be a crucial first step. Moreover, it is essential to consider the energy implications of the future of DeFi, especially as Bitcoin becomes a main player. Implementing Bitcoin mining regulations could help curb the increase in energy usage in the DeFi market. As the world pays close attention to the U.S.'s actions in this field, establishing mining regulations in the U.S. could serve as a role model for other countries to emulate. In addition, other assets such as Stablecoins and tokens are becoming increasingly important assets in the DeFi ecosystem. For example, Stablecoin is playing a crucial role in connecting DeFi protocols with traditional financial markets and is widely used in the DeFi lending markets for its natural being non-volatile in prices. Therefore, there is an urgent need to establish a new regulatory framework for improving transparency and security in DeFi.

5. Stablecoins

5.1. Background

The Stablecoin industry has faced increased scrutiny from legislators and regulators in the recent past due to several risk-related events that have raised doubts from authorities and stakeholders. In May of 2022, algorithmic Stablecoin UST and its companion coin LUNA collapsed as it depegged from the USD. Other controversies have called into question the stability of Stablecoins: Tether - the issuer of UST - was the object of an investigation by New York Attorney General Letitia James, who accused it and another Stablecoin issuer of false claims that they were 100% backed by the U.S. dollar; in February of 2023, the New York Department of Financial Services (NYDFS) directed Paxos Trust to stop issuing BUSD and the SEC informed the firm of potential charges related to its relationship with Binance. Finally, in the aftermath of the collapse of Silicon Valley Bank in March, 2023 Circle's USDC temporarily lost its peg to the USD.³⁰

5.2. Leading Actors

As of April 2023, Stablecoins have a combined market capitalization of \$136 billion. US dollar-pegged coins make up the majority of the global Stablecoin market, for instance, the largest Stablecoin pegged to an asset other than the USD is the Euro-pegged STASIS EURO (EURS), with only \$134M in market capitalization. USDT, which is issued by Tether, makes up 58% of the market share at \$77 billion. USDC, issued by Circle, makes up 26% of the market share at \$35 billion. Binance USD (BUSD) 6% with \$8 billion and USDP less than 1% at \$900 million, both issued by Paxos Trust.

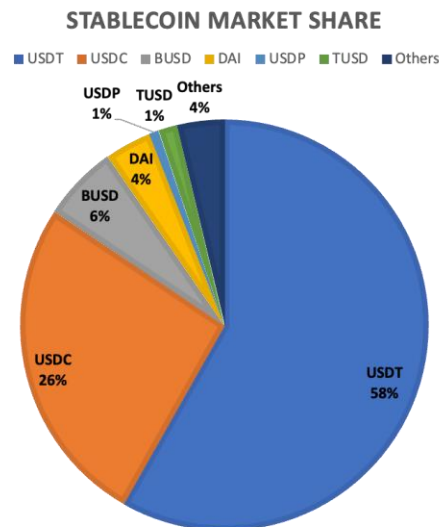


Figure 8 - Stablecoin Market Share

³⁰ For a detailed background on the stablecoin industry, see Annex 2.

5.3. Energy Implications

As discussed throughout this paper, the energy impact of each digital asset depends on the consensus mechanism used and the volume traded on them. The four leading actors listed above combined use around 11 different consensus mechanisms. The chart below describes the blockchains and consensus mechanisms related to the four main actors and their most recent 24-hour trading volume.

| | Volume (24h) | Blockchains | Consensus Mechanisms |
|------------------|--------------|---|---------------------------------------|
| USDT (Tether) | \$24B | Ethereum, EOS, Tezos, BTC, Cash SLOP, Liquid, Omni, Polygon, TRON, Solana, Statemine, Avalanche | PoS, DPoS, PoW, LPoS, PoH, NPoS, Snow |
| USDC (Circle) | \$4B | Ethereum, Solana, Avalanche, Tron, Alogrand, Stellar, Flow, Hedra, | PoS, PoH, Snow, SCP, Hashgraph |
| BUSD (Paxos) | \$8B | BNB Smart Chain, BNB Beacon Chain, Avalanche, Polygon, TRON, Optimism | PoSA, Snow, DPoS, PoS |
| USDP (Paxos) | \$2M | Ethereum, Binance Smart Chain, Fantom | PoS, PoSA, Lachesis |

Figure 9 -Blockchains, consensus mechanism and trading volume (24 hours)

As shown in the chart, only one of the four leading supports PoW. The second most energy intensive consensus mechanism used by the leading Stablecoin actors is PoS (which is 99.95% more efficient than PoW), followed by Delegated Proof of Stake (DPoS). It should be noted that data on the relative energy intensity of consensus mechanisms is limited and the energy intensity of some of the mechanisms listed above is unknown. However, it is important to note that a large portion of these consensus mechanisms are iterations of PoS and, even those that are not, were created with the objective of reducing energy intensity and scalability problems of PoW, and are considered to be more energy efficient.

With the data available, it is reasonable to conclude that the leading Stablecoins, and thus the Stablecoin market, do not represent a material portion of the energy consumption of all digital assets due to the consensus mechanisms they use to operate. As stated above, most research on the energy consumption of digital assets focuses on Bitcoin, however, an article from researchers at the University of Munich, *Energy Consumption of Cryptocurrencies Beyond Bitcoin*, provides a list of the top twenty most energy intensive coins on the market (2020), none of which are the four leading Stablecoins.

The main takeaway from the analysis of this data is that the Stablecoin sector has solved the energy consumption issue by implementing PoS and other iterations of it as consensus mechanisms, and if they continue on this path, they will contribute to an energy efficient future of money. However, it will be important to keep an eye on the use of PoW backed Stablecoins, since there is always the possibility of new players rising or current issuers migrating to PoW, with the argument of pursuing a more secure and immutable protocol than PoS.

5.4. Challenges

As stated before, Stablecoins have been the object of recent debates around regulation and supervision due to high-profile cases of mismanagement. However, discussion around the proper way to regulate this type of digital asset has been on the table for a while.³¹

In the U.S., legislators have made it clear that regulating Stablecoins is a top priority when it comes to the digital asset industry. An important legislation proposal was introduced to the Senate in December 2022, the Stablecoin TRUST Act, under which payment Stablecoins would be regulated by the Office of the Comptroller of the Currency and issuers would need to be fully backed by high-quality liquid assets. Payment Stablecoin holders would have priority in the event of an issuer's insolvency, and the bill clarifies that they are not securities and not under the jurisdiction of the SEC or CFTC. The bill would not affect non-payment Stablecoins and would allow state banking supervisors to impose additional regulatory standards.

Similarly, an important example of Stablecoin specific regulation at state level was implemented by the New York Department of Financial Services in June 2022. The Virtual Currency Guidance issued by the NYDFS is directed at entities that are regulated under Part 200 of Title 23 of the New York State Codes, Rules, and Regulations that issue USD backed Stablecoins, that is, companies that operate under a BitLicense or a charter as a limited purpose trust company under the New York Banking Law. The guidance establishes requirements for Redeemability, Reserve management, and external audits.

However, after recent discussions, the U.S. House of Representatives Financial Services Committee released a discussion draft bill on April 15th, aimed at creating a regulatory framework for Stablecoins. The bill would put the Federal Reserve in charge of non-bank Stablecoins and require registration for issuers wishing to conduct business in the U.S.. Credit unions and banks wanting to issue their own Stablecoins would require approval from the National Credit Union Administration, Federal Deposit Insurance Corp., or Office of the Comptroller of the Currency. The bill also includes a two-year ban on Stablecoins that are not backed by a hard asset, and it directs the Treasury Department to study such "endogenously backed" Stablecoins. Banking regulators and the National Institute of Standards and Technology would be able to set standards for interoperability between Stablecoins to allow for ease of use. The bill would also direct the Federal Reserve to study the effects of a digital dollar issued by the central bank, including its potential impacts on monetary policy, financial stability, and privacy.

Moreover, on April 19th, 2023 the the Digital Assets, Financial Technology and Inclusion Committee held a hearing with the objective of understanding Stablecoins' role in payments and the need for legislation that included industry experts Adrienne Harris from the New York State Department of Financial Services, Dante Disparte from Circle, whom we also interviewed as an expert during our research, Austin Campbell from Columbia Business School, Jake Cheervinsky from the Blockchain Association, and Delicia Reynolds Hand from Consumer Reports³². The main takeaway from the hearing was the common objective of both authorities, market participants and industry experts, to regulate the space;

³¹ For a detailed description of relevant regulatory proposals, see Annex 2.

³² For a detailed summary of the hearing, see Annex 2.

there was a general sense of urgency towards addressing the lack of regulation. Mr. Disparte's testimony stood out due to the proposal of Policy Principles based on Circle's experience as an issuer, and the use-case presented in which Circle partnered with the United Nations High Commissioner for Refugees to enable real-time secure, transparent, and auditable transfer of USD based humanitarian assistance, highlighting the ability of Stablecoins such as USDC to expand the reach and capabilities of the traditional financial system by leveraging technology.

Additionally, within the European Union (EU)'s Markets in Crypto Assets (MiCA) regulation applies to Stablecoins and categorizes them as Asset-Referenced Tokens (ARTs) or E-Money Tokens (EMTs), the former being backed by multiple currencies, commodities or cryptocurrencies, while the latter are only linked to a single currency. This regulation allows for the designation of significant Stablecoins (sEMTs and sARTs) subject to more stringent rules, including capital requirements and EBA supervision. EMTs can only be offered by authorized institutions with prior notification to supervisory authorities, while ARTs must be established in the EU and face a detailed catalog of duties and rules, including capital requirements and asset reserves to prevent liquidity risks. MiCA also limits the daily average number of transactions and trading volume associated with EMTs and ARTs, but not all transactions will be considered associated with uses as a means of exchange.

It is safe to conclude that proper regulation is the most challenging issue that the Stablecoin sector is facing at the moment, as governments and financial regulators seek the proper balance between safe rules and space for innovation. However, rules and regulations can only go so far, and the industry has still yet to prove that Stablecoins can actually be relied upon to maintain a 1:1 parity, even when following best practices regarding reserves management and external auditing.

A perfect example of this can be observed in the recent events that followed the bank run on Silicon Valley Bank (SVB), in which USDC briefly de-pegged over the weekend of March 11th, due to concerns that the company could lose the \$3.3B deposited at SVB. This time, the U.S. Treasury Department intervened and ensured that all deposits within SVB were secured by the government and depositors were guaranteed to recover 100% of their funds. However, the Stablecoins' struggles suggest more financial turmoil is in store, as markets fully digest the collapse of SVB. USDC is generally backed by 100% U.S. dollars or short-term U.S. treasuries, aiming to make the tokens always redeemable 1:1 for actual dollars in a traditional bank account. However, USDC's value proposition is in question, and if the FDIC had not covered 100% of USDC's reserves held at SVB, it may have had to pay the difference out of company funds or raise money from investors, which would have in turn endangered Circle's solvency.

It is safe to assume that the SVB case will serve as a future example for regulators to further pursue proper regulation around reserves and risk management in the Stablecoin section. Furthermore, it will be an important example for issuers, as concerns that instability in the traditional financial sector can affect the Stablecoin industry have been proved right. Moving forward, we foresee responsible issuers moving towards a more balanced approach when it comes to reserves management, perhaps favoring more USD deposits over government bonds to avoid a maturity mismatch, and further diversifying their reserves with various financial institutions.

5.5. The Future of Stablecoins

Based on our research, the report concluded that the Stablecoin sector needs to focus on two main efforts to ensure a successful transition of this technology into the future of money:

Industry Regulation. The industry has reached a point in which proper regulation is essential for responsible growth and innovation. Stablecoin issuers are being trusted by customers to keep custody of their assets, and they are being led to believe that there is virtually no risk in this, as if they were holding their money at a traditional commercial bank. This is not only a tremendous responsibility, but also a privilege, and issuers themselves need to make sure that there are reasonable and trustworthy rules and regulations that allow them to keep their promises to their customers. The regulations that are produced as part of this effort should not only be technical and specific, but they also need to be global and flexible enough to be applied to new iterations of Stablecoins. It is crucial that industry players work together with authorities to ensure a proper understanding of what the technology is trying to achieve, while protecting the rights of consumers and the financial stability of our global economy.

Regulators should establish clear guidelines for reserve management, with the main objective of ensuring that the issuer properly manages the risk of depegging, as it is the main value proposition of the product. Also, there must be a guarantee for consumer protection and oversight of redeemability processes as well as the offering of adjacent financial products. It is important to remember that there is a positive correlation between innovation and crises, risk environments make for the creation of great companies and technologies that ultimately benefit the consumer - as stated by industry expert and Coinbase Strategy Lead John D’Agostino during our research interview - however, regulators must strive for responsible innovation, the balance will be hard to find, but authorities must try to rise up to the challenge.

“Regulation should allow people to experiment earlier [and] create an environment where companies that want to take the risks can.”

- John D’Agostino, Coinbase

In that sense, it is important to remember that the main value proposition of Stablecoin issuers is their ability to create and manage superior technology behind their product, which would differentiate them from Central Bank Digital Currencies (CBDCs) and tokenized deposits. In the words of our guest industry expert, Circle’s Dante Disparte: “Any time that technology is still protagonist in a conversation, it is still very early for that industry, and when Central Banks decide to go down the path of creating and launching CBDCs, Stablecoins will be leaps and bounds ahead of them”.

Finally, as for the authorities that are best equipped to regulate the sector, we have come to the conclusion that there are, in general, three options: 1) The Central Bank, as it is a technology that resembles fiat and e-money and will eventually affect how the money market works; 2) The main banking regulator, as the business model resembles that of a bank, with tokens being stored instead of traditional deposits, and especially if adjacent financial products, such as staking programs that produce returns, are being offered; and 3) The capital markets regulator, since there is

an argument for certain kinds of tokens to be considered either securities or commodities. In the case of Europe, it seems to be clear that the European Parliament will establish a mixed approach, with the European Banking Authority (EBA) and the European Securities and Markets Authority (ESMA) establishing the guidelines at the union level, and each member state designating the national authority responsible for this market. As for the US, both the SEC and CFTC have expressed interest in exercising their jurisdiction over the space, and it will remain unclear until legislation is passed, unless they attempt to regulate without legislative action via a conditional exemption³³.

Energy Efficiency: As shown by the research and data within this section, technological innovation has allowed the Stablecoin sector to avoid high energy consumption by supporting energy efficient blockchains. However, we believe that there is an opportunity for this industry to not only avoid being a problem within the energy implications of digital assets, but actually becoming a positive force and making our energy markets more efficient. By understanding the value creation and how it is specifically tied to the energy consumed by the issuance and transacting of Stablecoins, there is a case to be made for increased energy efficiency.

One example that can be used as a case study moving forward would be the creation of value relative to the energy consumed in international payments. It is important to remember that the PoS consensus mechanism is 99% more energy efficient than the original PoW, with this in mind, not only has utilization of blockchain technology for crossborder financial transfers has become more effective at a technological level, but also within an energy efficiency lens. With entire blockchains, such as Ethereum, being able to operate at scale with the energy consumption of one household per year, it is very possible that a Stablecoin, USDC, for example, could become a very energy efficient and practical way to transfer value around the globe. This has to be compared to the traditional financial system on several levels, the Society for Worldwide Interbank Financial Transfers (SWIFT) mechanism that is currently the main way of transferring funds internationally relies on data centers, processors, a variety of intermediaries, and several standardization mechanisms that have been, until recently, the best way to achieve international payments. However, it is very likely that scaling an interoperable network of global payments supported by the use of Stablecoins would provide the same service within a fraction of the time (virtually instant) and less energy consumption. It is important, nonetheless, to state that national payments technologies - such as instant retail payments systems - have reached a level of sophistication that could compete with the Stablecoin case, but it would have to be integrated globally.

³³ This was discussed in detail by our team with industry expert Ryne Miller, former FTX US General Counsel, CFTC official, and experienced capital markets and regulatory attorney.

6. Central Bank Digital Currencies (CBDCs)

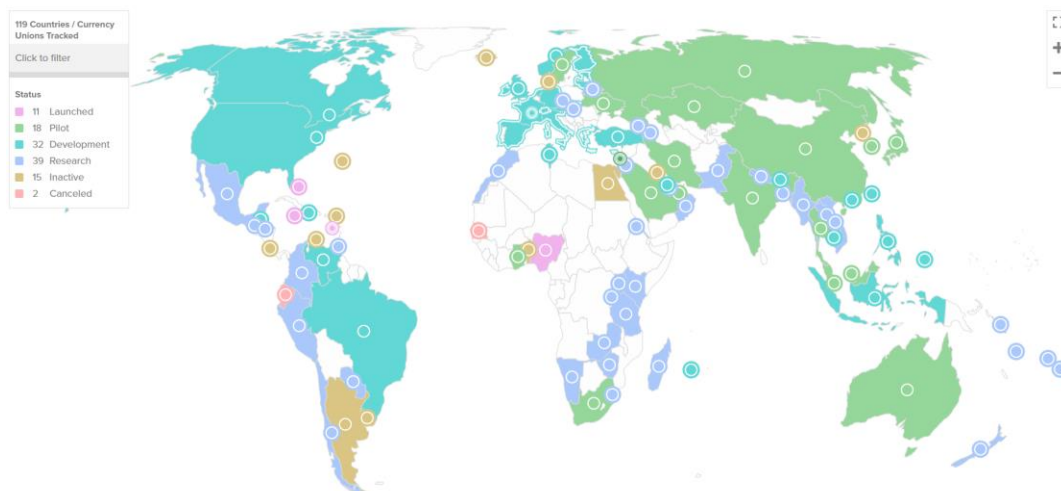


Figure 10 - Countries in various stages of CBDC development. Source: The Atlantic Council's CBDC Tracker

6.1. Status quo

In March 2023, 114 countries, representing over 95% of global GDP, were exploring a CBDC. This constitutes a significant increase from May 2020, when only 35 countries were assessing the utility of this particular type of digital currency. At the indicated date, according to the Atlantic Council, approximately 60 countries were in an advanced phase of exploration (development, pilot, or launch). Table 1 (Annex 1) provides a summary of different CBDC developing stages.³⁴

6.2. Challenges of Adopting a CBDC

CBDCs pose significant challenges to policymakers. In addition to the lack of previous ample experience with CBDCs, low central banks resources necessary to implement digital-intensive projects, and potentially limited willingness of the population to adopt digital payments, central bank currencies can be beset by the following issues:

- **Cyberattacks.** Financial stability and data privacy can be threatened by unsafe implementations.³⁵ Both retail CBDCs (rCBDCs) and wholesale CBDCs (wCBDCs) are prone to cyberattacks.
- **Run on banks.** People might use the benefits of a CBDC (instant transfer of money) in order to safeguard their funds. E.g., transfer funds en masse during crises.
- **Various technical issues.** Lack of internet connectivity in rural areas and limited interoperability with existing payment systems might hinder CBDC implementation. Technical errors during operation have the potential to disrupt the financial system. Research and development of certain technologies can take a long time.

³⁴ Atlantic Council. (2023). CBDC Tracker.

³⁵ Congressional Research Service. (February 2022). *Central Bank Digital Currencies: Policy Issues*. p. 24.

- **Current legislation** and **low financial literacy** can represent implementation barriers.
- **Existing payment systems**, depending on their effectiveness, reduce the incentives of implementing a CBDC. For instance, the U.S. Federal Reserve will launch the FedNow Service, a new instant payment infrastructure that facilitates safe and instant payments for financial institutions, in July 2023. However, Josh Lipsky, senior director of the Atlantic Council’s GeoEconomics Center, stated that because of the long time required for its development, the technology utilized is six to seven years old. Therefore, policymakers should evaluate existing payment systems and their capabilities with the aim of understanding the need for a CBDC.

6.3. Energy Implications of CBDCs

The energy implications of CBDCs depend largely on the design choices made in the supporting DLT network³⁶. As previously discussed in this document, the consensus mechanism used to achieve agreement about the present state of the network is one important design element that can greatly affect energy consumption.

Not only PoW-based systems are less energy efficient, but other characteristics undermine the suitability of PoW as a consensus mechanism for CBDC. In financial market infrastructures, privacy is an essential requirement to ensure that sensitive information is not disclosed to unauthorized parties. However, in a PoW-based CBDC all transactions are visible to everyone, which may violate banking laws and put certain parties involved in transactions at a disadvantage.³⁷ Additionally, in a CBDC system, it is essential to have a certain level of control over who can participate and how transactions are verified. However, in a PoW-based system, anyone can join the network and participate in the consensus process anonymously, making it difficult to regulate and control the system.³⁸

This was one of the main conclusions of Project Jasper, the CBDC pilot program launched by the Central Bank of Canada. In the phase 1, the system was built on the Ethereum platform, which, at that moment, used a PoW consensus protocol. The lessons learned from this first phase of the project included evidence that “[i]n a closed, private network, like a wholesale payment system, PoW protocols are neither necessary nor desired. Restricting access to trusted counterparties enables developers of DLT protocols to use alternative efficient protocols to perform the validation and recording functions”³⁹. In fact, the key conclusions from Phase 1 and 2 of Project Jasper are that DLT platforms that employ a PoW consensus protocol, as used in Phase 1, do not deliver the required settlement finality and low operational risk.

Another design element that can influence energy consumption is the level of control that can be exercised on the underlying architecture (See Figure 10). Permissioned networks, which allow for stronger controls on parameters that influence the energy consumption of the core processing infrastructure, could potentially be more energy-efficient

³⁶ CBDC is not tied to blockchain technology and can thus be adopted through other digital payment solutions. Lee, Sooyang; Park, Jinhee (2022). *Environmental Implications of a Central Bank Digital Currency*. World Bank Group. The scope of the analysis presented here will be limited to the CBDC to the blockchain-based system.

³⁷ Bank of Canada (June 2017). *Financial System Review. Project Jasper: Are Distributed Wholesale Payment Systems Feasible Yet?*

³⁸ *Idem*.

³⁹ *Idem*.

than permissionless networks that allow anyone to join as a validator⁴⁰. Controlled and managed by a Central Bank, CBDC does not require energy-intensive mechanisms to prove its legitimacy through its technological structure⁴¹.

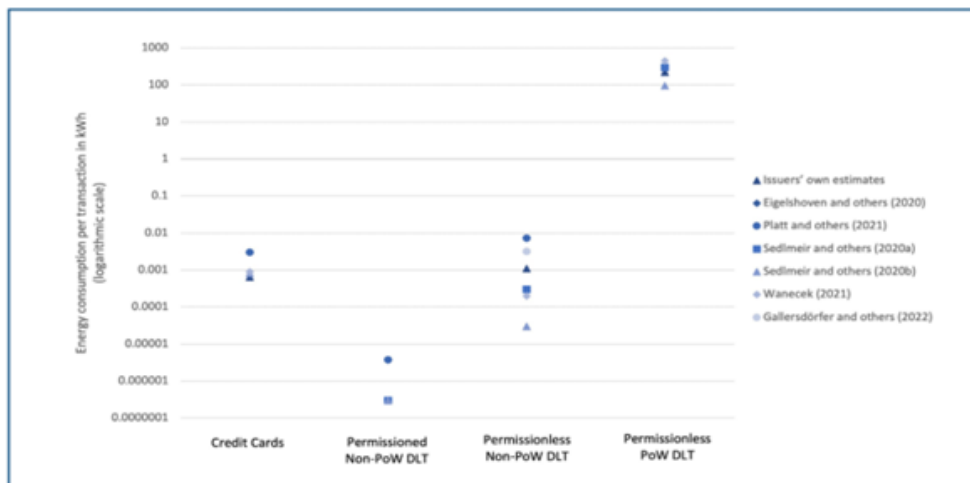


Figure 11 - Estimates of Energy Use (in kWh) per Transaction for the Core Processing of Different Payment Systems. Source: International Monetary Fund, p. 9 Notes: For cases in which a source provides multiple estimates, the figure displays the midpoint.

Given the limitations of PoW-based systems, CBDC initiatives based on DLT technology choose non-PoW permissioned systems, which are the most energy efficient even if compared with traditional payment methods such as credit cards. In this regard, CBDC does not pose a concrete threat to sustainability, but, instead, it may constitute a potential tool for reducing energy consumption or limiting market failures in the energy market.

For instance, in areas where renewable energy sources like solar or wind power are abundant, CBDC transactions can be powered by renewable energy sources. This can help promote the adoption of renewable energy and reduce reliance on non-renewable sources of energy, which can be beneficial for the energy crisis.

Also, governments may use CBDC as a tool to facilitate a carbon-free economy. For instance, the project presented in the European Commission *Funding and Tender Opportunities*, Blockchained Green-Money for Carbon Free Economy, involves designing a low-cost retail CBDC that will be used to distribute money to economic agents such as households, enterprises, NGOs, and local governments. The purpose of this distribution is to incentivize abatement of CO2 emissions by these economic agents, promoting a carbon-free economy. By using a digital currency, the cost of distribution is significantly reduced compared to traditional methods of payment distribution. Also, by using a CBDC, the project can reach a wider range of economic agents who may not have access to traditional banking services. This inclusion can help boost economic growth and provide equal opportunities for all participants in the economy.

Another example is Carbon Quantitative Easing (CQE). CQE is a proposed monetary policy to manage the risks of climate change using a CBDC that is pegged to the global carbon stock-take. The CBDC is linked to a transparent

⁴⁰ International Monetary Fund (IMF). (June 2022). *Digital Currencies and Energy Consumptions*.

⁴¹ Lee, Sooyhang; Park, Jinhee (2022). *Op. cit.*

accounting system that rewards low-carbon projects, making them more profitable and encouraging investment in climate mitigation and restoration. By pricing the risk of unwanted climate change into all investment decisions, CQE encourages the investment in low-carbon projects and reduces private debt, improving the quality of economic growth. Overall, the use of CBDC in CQE can help to support the transition to a low-carbon economy and manage the risks of climate change⁴².

6.4. Climate Implications of CBDCs

The short-, medium-, and long-term impact of CBDCs cannot be described only in terms of energy consumption. In other words, CBDCs (e.g., their ability to increase efficiency of settlements and post-market activities) generate beneficial outcomes: due to the fact that a digital currency lowers operational costs and replaces - to a certain degree - physical cash, *the negative impact of standard fiat currencies is reduced*. Although CO₂ emissions related to cash supplies are small in comparison to other sectors of the economy (transportation, agriculture, etc.), the environment is affected as a result of the three main stages in the life cycle of currency (namely, “production, operation, and end of life”).⁴³ Each of these phases is resource-intensive and consists of sub-stages, including processing, counting, sorting, transportation, and storage.

Research conducted by Tufts University’s Institute for Business in the Global Context indicates that the total environmental cost of a U.S. banknote is \$2.20. In addition, the average lifetime of a U.S. dollar averages 8.6 years.⁴⁴ Based on these numbers, the U.S. dollars generate “\$0.26 worth of CO₂ annually” per banknote. Similar calculations suggest that a Bitcoin produces \$70 worth of CO₂ emissions each year. When accounting for all U.S. dollars in circulation and all mined Bitcoins, reports concluded that the total annual environmental cost of U.S. money is \$12.9 billion, while this particular cryptocurrency amounts to \$1.3 billion in environmental costs per year.⁴⁵

Several assessments of the International Monetary Fund (IMF) bring to the forefront the fact that CBDCs are estimated to have energy consumption patterns similar to those of the current (Visa and Mastercard) card payment system.⁴⁶ In other words, CBDCs can reduce the negative climate impact of fiat currencies.

6.5. Democratic & Autocratic Use Scenarios

Authoritarian regimes or states experiencing democratic backsliding can utilize CBDCs to circumvent international sanctions, amass significant amounts of data about domestic users, and tighten control over the national financial system.^{47,48} For instance, the characteristics of Chinese rCBDC and wCBDC projects (see Annex 1)

⁴² Global Carbon Reward. (September 2019). *First Annual Global Climate Restoration Forum*. The United Nations Headquarters.

⁴³ Digital Planet - The Fletcher School’s Institute for Business in the Global Context. (October 2021). *How Green is the Greenback? An Analysis of the Environmental Costs of Cash in the United States*.

⁴⁴ Digital Planet - The Fletcher School’s Institute for Business in the Global Context. *Source cit.*

⁴⁵ *Idem*.

⁴⁶ International Monetary Fund (IMF). (June 2022). pp. 11-12.

⁴⁷ Jiang, J. and Lucero, K. (January 11, 2021). Background and Implications of China’s Central Bank Digital Currency: E-CNY. *SSRN Electrical Journal*. p. 12.

⁴⁸ Greene, R. (July 2021). *What Will Be the Impact of China’s State-Sponsored Digital Currency?* Carnegie Endowment for International Peace.

demonstrate the government’s capability not only to increase the “surveillance of financial transactions” in comparison to extant payment systems,⁴⁹ but also to circumvent international sanctions. Moreover, a wider implementation of e-CNY will create the mechanisms necessary to supervise all transactions, swiftly stop payments, collect financial information, and sanction entities that do not comply with the Chinese Communist Party’s agenda. In other words, authoritarian leaders will be provided with the “unprecedented, real-time control over the economic rights and capabilities of individuals”. Hence, they will be able to unilaterally and “effectively freeze individuals or institutions out of the financial system.”⁵⁰

General Secretary Xi Jinping described financial security in the following terms: “controlling people, watching money, tightening the system firewall.”⁵¹ Regarding sanction avoidance, certain steps were already taken in 2021: the Ministry of Commerce adopted a blocking statute that might force businesses activating in China to ignore U.S. sanctions if their compliance harms Chinese entities or citizens; and the National People’s Congress Standing Committee passed regulations that empower Chinese authorities to seize the assets of or ban economic activities of companies that harm Chinese individuals by adhering to U.S. sanctions.

An interview completed by our team with Yaya J. Fanusie, Adjunct Senior Fellow at the Center for a New American Security (CNAS), revealed that the potential of states to use CBDCs as an instrument of averting international sanctions and tightening control over their citizens is real but it will take time to become potent. The latter will happen when reliance on banks and payment service providers for various services within the CBDC architecture will decrease. However, current trends in data collection persuaded the aforesaid expert to state that “data is the new electricity and China’s economy works on data”; hence, he assesses that countries with similar authoritarian regimes will, at some point, reap the benefits of increased access to money flows facilitated by CBDCs.

In stark contrast, the EU’s endeavors focus on promoting democratic values (transparency, security of personal data, accountability, equal representation of stakeholders in the design process etc.), privacy, and sustainable development. Nevertheless, Michelle W. Bowman, a member of the Federal Reserve Board of Governors, astutely observed that even democracies will struggle with the potential of CBDCs to limit civil rights and liberties. She argues that the programmability of CBDCs might be employed “to control or even harm consumers and businesses”.⁵² An opportunity to increase influence over money flows can lead to the “politicization of the payments system” which, in turn, opens the door for pernicious endeavors that suit the agenda of a limited number of people.

6.6. Policy Recommendations

CBDCs, once implemented in various jurisdictions, will represent an important component of both national and international financial systems. Therefore, policy recommendations are vital in guiding future endeavors meant to design this particular type of digital asset.

⁴⁹ *Idem.*

⁵⁰ Stanford Law School. (April 2021). *Background and Implications of China’s Central Bank Digital Currency: E-CNY.*

⁵¹ Greene, R. (July 2021). *Op. cit.*

⁵² Federal Reserve (April 18, 2023). *Considerations for a Central Bank Digital Currency.*

Technology. Some CBDC experiments indicated that DLT might not be able to provide the required capacity to intensively store data or process transactions.⁵³ Hybrid architectures can be employed to fulfill different policy outcomes: in certain use case scenarios, DLT might provide advantages in comparison to other technologies. Non-PoW permissioned systems should be used to reduce the impact on climate by decreasing energy consumption. In addition, technologies must be updated constantly with the purpose of (1) facilitating access to novel features, (2) maintaining or increasing security levels, and (3) complying with new regulations and standards.

Legislation. We recommend that central banks start debates about regulatory frameworks as early as possible in the development process of a CBDC. While law reform, in many cases, is not necessary during the pilot stage, a roll-out might require new legislation.

Climate-related recommendations. In order to ensure the energy efficiency of CBDCs, central banks can adopt a holistic approach that considers the entire technology stack, including the ledger design, supporting platforms, and hardware. This would be achieved by explicitly incorporating energy consumption and carbon footprint as selection criteria for all components of the CBDC ecosystem. The G7 Public Policy Principles for Retail Central Bank Digital Currencies⁵⁴ highlight the need of central banks to consider disclosure of the environmental impact of CBDC operations.

Security. Cybersecurity should represent a serious focus area for all central banks. We suggest either developing in-house task forces or contracting professional cybersecurity firms capable of providing support during all stages pertaining to the design and implementation of a CBDC. Furthermore, we recommend central banks to avoid relying on a single technology supplier and, where it is possible, to develop internal resources while employing different contractors in accordance with strict safety principles and procedures. Reliance on a single technology supplier for the design, development, launch, and management of a CBDC might lead to “data hoarding and abuse of personal data by commercial parties”⁵⁵ in the absence of specific anonymity measures.

International standards. Countries should utilize current multilateral agreements, legal frameworks, and established institutions (IMF’s Monetary and Capital Markets Department) and procedures with the aim of creating coherent global standards regarding the role of CBDCs in the international financial system. While many countries are engaged in research, there is a shortage of reliable data; therefore, a common set of guidelines and standards will provide support to latecomers and promote rule-based financial interactions. A global framework supporting the issuance of CBDCs would represent a novel iteration of the Bretton Woods system. Namely, greater cooperation and stability would be nurtured in a rule-based environment monitored by specialized bodies.

Privacy. Depending on policy goals, CBDCs can generate different trade-offs. Data privacy is important but high anonymity can thwart AML/CFT endeavors. As a result, we suggest a CBDC model with multi-tiered wallets

⁵³ IMF. (February 2022). pp. 16-17.

⁵⁴ G7 Countries. (October 2021). *G7 Public Policy Principles for Retail Central Bank Digital Currencies*.

⁵⁵ BIS Innovation Hub. (June 2021). *BIS Annual Economic Report 2021*. pp. 84-85.

connected to different “levels of thresholds”⁵⁶: wallets with low transaction limits can still foster financial inclusion because they allow greater anonymity.

Cooperation. Central banks are advised to reach out, cooperate and coordinate with all stakeholders: users, private sector intermediaries, government agencies, political bodies and within them.

6.7. Future of CBDCs

A significant number of countries pursue CBDC projects but limited experience with active central bank digital assets renders predictions extremely difficult. Nevertheless, it is very likely that a type II CBDC model (namely, intermediated CBDCs) as described by the IMF will prevail and even be employed for cross-border payments. In addition, CBDCs are expected to be designed in a way that promotes energy efficiency and limits the negative impact on climate. As technology continues to advance, the potential benefits of CBDCs are likely to become more apparent.

The report agrees with Josh Lipsky, the senior director of the Atlantic Council’s GeoEconomics Center, and his statement encompassed in the interview conducted specifically for this study: the most probable future entails a fragmented ecosystem (“splintered environment”) in which Stablecoins coexist with various regional currency networks based on compatible cross-border CBDCs.⁵⁷ Moreover, this outcome will be the result of a heterogeneous evolution of digital assets at global level: some countries will innovate and adopt CBDCs earlier, while others will wait to identify best practices. The aforementioned Atlantic Council director considers that the future of CBDCs is interconnected with developments in usage patterns of other digital assets; for instance, many central banks will try to avoid the dollarization of their economies through Stablecoins pegged in U.S. dollars. As a result, if Stablecoins’ popularity increases, there is a higher chance for governments to accelerate existing CBDC projects. According to Josh Lipsky, in certain jurisdictions (i.e., Nigeria), the introduction of a CBDC led to increased usage of cryptocurrencies.

An international fragmented ecosystem similar to the one predicted by Lipsky would oppose two different types of regional currency networks: a) a CBDC nexus pertaining to G20 democracies based on transparency, accountability, and high levels of data privacy and b) a cross-border CBDC hub encompassing authoritarian regimes such as Russia, China, and Iran. The latter will utilize digital assets as a propitious avenue for i) the avoidance of the U.S.-designed sanctions, ii) strengthening domestic control of financial systems, iii) the increased surveillance of citizens and crackdown on dissent, and iv) the promotion of network / digital sovereignty principles. While interactions between these two types of networks will exist based on predicted interoperability among cross-border CBDC models (i.e., governments will not accept or promote the complete isolation of their digital currencies from the international payment systems), the global economy will suffer from a larger dependency on close-knit alliances stemming from resembling agendas, ideological convictions, and value systems.

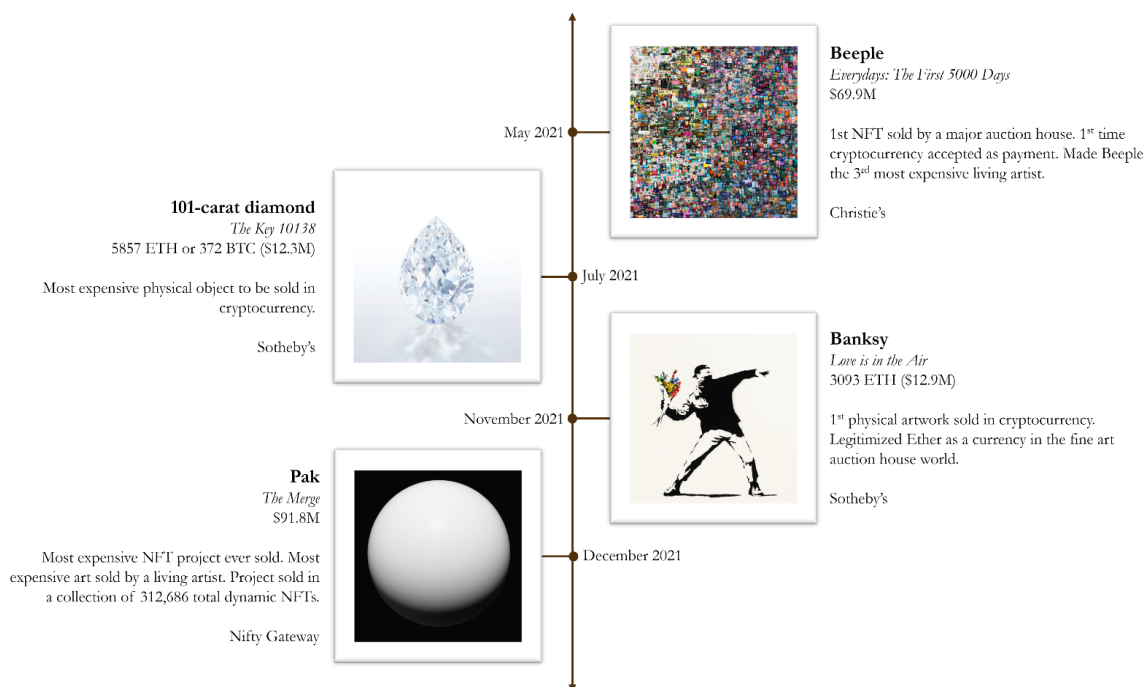
⁵⁶ IMF. (February 2022). p. 13.

⁵⁷ The interview took place online, on March 30, 2023.

The Bank for International Settlements describes the future monetary system as “a tree whose solid trunk is the central bank”.⁵⁸ In our vision, the aforesaid trunk encompasses multiple layers of digital assets (cryptocurrencies, Stablecoins, CBDCs) that coalesce to form a more diverse, secure, efficient, and sustainable financial system. As the world economy will move towards a basket of currencies (Stablecoins, CBDCs, fiat currencies, Layer 1 and Layer 2 networks),⁵⁹ the dominance of the U.S. dollar will be challenged. The latter phenomenon will prompt a response from the U.S. that will include, inter alia, the issuance of a digital dollar. Nevertheless, recent debates regarding the Treasury’s report entitled “The Future of Money and Payments”⁶⁰ serve as proof that a U.S. digital dollar will not be at the forefront of the CBDC movement. As Dante Disparte, Chief Strategy Officer and Head of Global Policy at Circle, stated “in the digital currency space race - the U.S. can win or lose; it is a choice.” Hence, the US seems comfortable in allowing other countries to experiment with CBDCs first.

7. Case Study: The Art World’s Blockchain Adoption

The art auction world presents a critical case study on the successful early adoption of digital assets while staying mindful of their energy impact. Old-guard art auction houses, like Sotheby’s and Christie’s, are embracing digital assets to create value. They are selling NFTs, auctioning in Ethereum, and exploring the future of blockchain technology and tokenization. By doing so, they are not only staying ahead of the competition but also reducing their energy impact and transforming the space. Their success and continued exploration serve as a prime example of the responsible and effective incorporation of digital assets in client-focused businesses, with lessons that can be translated from the art world to the financial services and beyond.



⁵⁸ BIS. (June 2022). *BIS Annual Economic Report 2022 - The future monetary system*. p. 92.

⁵⁹ Michael B. Greenwald. (May 2022). Harvard Kennedy School Belfer Center. *What Will Determine the Future of Money?*

⁶⁰ The Treasury Department. (September 2022). *The Future of Money and Payments*.

The art auction houses' incorporation and continued exploration of digital assets has and will continue to provide:

Business Incentives. Streamlining time-intensive business operations, growing client base, increasing revenue streams, enhancing privacy and security.

Figure 12 - Timeline of major art sales involving digital assets.

Use-Cases. Current and near future applications reduce energy consumption, increase security, and decrease time costs. This successful adoption will rely on seamless integration, usability improvements, and client demand.

Energy Impact Reduction. Using PoS, moving time and transportation-intensive operations on-chain, and promoting energy system mindfulness will reduce energy costs, time and transportation costs, and carbon footprints.

The following pages describe these market effects, use-cases, energy impacts, and financial services applications.

7.1. Background

In May 2021, Beeple's \$69.9M NFT sale through Christie's marked the beginning of the major art auction houses catapulting into the digital asset space by embracing cryptocurrency, tokenization, and the potential of blockchain. Shortly after, in November 2021, Banksy's "Love in the Air" art was the first physical artwork paid for in Ethereum at a Sotheby's auction, which helped legitimize ETH as a currency.

As competitor-aware, client-focused businesses, the auction houses' digital foray was fueled by a combination of growing market trends and client interest. In 2021, NFT marketplaces (OpenSea, Nifty Gateway, and SuperRare) were growing,⁶¹ collectors were engaging with this medium,⁶² and blockchain technology was experimented with. In addition, they saw client interest from a few asking to use cryptocurrency as payment.⁶³ This space created a potential to be relevant to new, tech-savvy collectors.

In the depths of the current bear market, NFT trading volumes have picked up again. This recovery phase is seeing a movement toward trading, gamification, and long-term utility,⁶⁴ and has the potential to build back stronger and more sustainably than before.

7.2. Business Incentives

Major art auction houses are leveraging decentralized assets like NFTs, tokenization, and Ethereum to add value and create value across the board. Incorporating these assets helps (1) streamline time-intensive operations, (2) grow their client base, and (3) increase revenue. In turn, this early adoption has legitimized the value of these digital assets in the fine art and collectibles world.

⁶¹ A record-breaking 2.4 million NFTs (worth \$4.8B) were exchanged on OpenSea in January 2021, despite the average NFT price fluctuating between \$6,900 and \$1,300 that month.

⁶² NFT trading volume increased from \$95M to \$25B from 2020 to 2021, according to DappRadar, which tracks over 30 blockchains.

⁶³ Senior expert in art auction house world

⁶⁴ Will Brooke, Creator Partnerships at OpenSea.

Erik Jansson, Chief Information Officer at Christie's, quoted that they "want to meet clients where they're at, and also be ahead of any risks that can destroy the market they operate in."

The successful incorporation of digital assets can do at least one of the following to build a sustainable strategy:⁶⁵

- 1. Process Efficiency:** Digital assets like tokenization, smart contracts, and blockchain building will streamline time-intensive business processes. In the art world, that means speeding up processes for authentication and provenance, reducing transaction times by 80%⁶⁶, and increasing the liquidity of assets. The financial services can use NFT smart contracts, tokenized invoices, and credit factoring to observe similar benefits.
- 2. Client Engagement:** NFTs and tokenization create an opportunity to expand and deepen a business' customer base. A senior expert in the art auction house world remarked that their client base was getting older and digital assets (curated NFTs, cryptocurrency payment options, redeemable tokens at sporting events) played a key role in attracting new, young, tech-savvy collectors to their platform. The trackability of digital assets also gives companies insight into the interests and movements of their existing clients to deepen relationships. The financial services can use app-integrated crypto wallets, digital collaborations, and tokenized processes to attract and engage customers with their brand as owners, collaborators, or clients.
- 3. Financial Incentive:** At the end of the day, revenue drives business. Sotheby's and Christie's combined generated over \$200M in sales in just 1 year from digital asset sales. Despite market capitulation, OpenSea sold over \$4.8B in NFTs in January 2022 alone. In the financial services, increased efficiency and a larger customer base will work together to increase revenue, especially in a space with the trading volume levels of NFTs and other digital assets.

The art auction houses' adoption and development of these digital assets has proved to be a symbiotic relationship. The recent incorporation of NFTs, cryptocurrency, and the blockchain with the simultaneous development of tokenization and blockchain building has and will continue to reduce energy impact, increase market competitiveness of art auction houses, legitimize the value of digital assets, and create security for the parties involved.

Platforms like Pace Verso are enabling digital artists to create digital art and are fostering an open market platform by providing the tools necessary to make this happen including giving recognition and proceeds to the artists directly. Sarah Meyohas, an NFT Artist and Investor, commented that "art as a form of alchemy, taking base materials and transforming it into something of the higher order." For artists like her, blockchain and these digital art platforms along with the NFTs to attribute, authenticate, and sell, are enabling her creativity not just in the digital world but also the physical world. Erik Jansson stated that without blockchain, there wouldn't be a real way to truly sell digital art.

7.3. Digital Asset Use-Cases

⁶⁵ PwC How to build a sustainable NFT strategy report.

⁶⁶ Filippo Chiricozzi, Banca Sella.

Before exploring the use-cases of tokenization, it is important to note that before these new technologies are fully incorporated, there needs to be a **process for seamless integration** into current systems, an **increase in usability** of wallets like MetaMask, and, most importantly, a **customer demand** for it. Usability is imperative to drive customer demand and the justification for future investment.

The art auction world has been using tokenization⁶⁷ to create value but is still exploring the new possibilities with this blockchain technology. In the near future, tokenization will be used to streamline time-intensive business processes, ensure secure transactions, and promote sustainable practices.

7.3.1. Increase Process Efficiency

Tokenization can create an art market with extremely secure authentication and provenance records, transaction efficiency, and increased accessibility and liquidity, all while decreasing the energy costs associated with packaging, ledgering, storing, and shipping these luxury goods around the world.

Authentication and Provenance. Authenticity and provenance are central to the art auction house market's legitimacy. However, the verification of these two factors is time and energy intensive. Using digital tokens to represent physical assets, like luxury watches or works of art, will ensure security and reduce the energy consumption associated with storing and transporting the physical asset across the world. The ownership and authenticity can be securely tracked, verified, and transferred on the blockchain platform which reduces the risk of fraud, enables more efficient management of the assets, and reduces energy use.

Transaction Efficiency. Tokenization and immutable smart contracts can reduce the time and cost associated with transactions, as well as improve the security and transparency of the process. This allows ownership of an asset to be transferred instantly and securely without intermediaries such as banks or brokers. This significantly reduces the energy consumed by intermediaries in traditional transaction processes, such as the energy required for bank processing and transportation.

Accessibility and Liquidity. Tokenization can increase liquidity and accessibility of the assets being sold while reducing energy consumption. By breaking down assets into smaller, tradeable units, tokenization enables fractional ownership, which can open up new investment opportunities for smaller investors who may not have had access to these assets previously. This can also help to increase the liquidity of the assets, as they can be traded more easily and frequently. As a result, energy consumption related to the transportation of physical assets will decrease.

7.3.2. Combating Illicit Finance

The art market can use NFTs and tokenization to stop illicit financing. Artworks can be tokenized and sold as NFTs on a blockchain-based platform, allowing for a more transparent and traceable market.

⁶⁷ There are three types of tokenization relevant: NFTs, redeemables, and title tokens. NFTs (non-fungible tokens) are stored on a blockchain and represent anything from digital art to collectible sports cards and virtual real estate. Redeemables are tokens that come with a physical object, mainly used by brands for promotional benefits. Title, or authenticity, tokens are ones that prove authenticity, provenance, and ownership.

In the traditional art market, artworks are often sold privately, making it difficult to track their ownership and value. This can create opportunities for money laundering, tax evasion, and other illicit financing activities. However, by tokenizing artworks as NFTs, each token can represent a unique piece of art and its ownership can be tracked on a public blockchain ledger, while still maintaining privacy for all parties involved. In addition, art auction houses like Christie's have made a huge commitment to combat money laundering activities in the art world and have partnered with Chainalysis, a company that provides data platforms to power investigation, compliance, and risk management tools to solve cyber-criminal cases and grow consumer access to cryptocurrency safely, to counter illicit finance.

A process example of how NFTs and tokenization can be used to stop illicit financing in the art market is stated below:

1. **Tokenization of Artwork.** A reputable art dealer creates a digital representation of a unique piece of art as an NFT. This NFT contains information such as the artist, title, medium, and provenance of the artwork.
2. **Auction or Sale of NFT.** The art dealer sells the NFT through an online auction or marketplace where buyers bid on the token. The sale of the NFT includes a smart contract that specifies the terms of the sale and automatically executes the transaction once the winning bid is confirmed.
3. **Payment and Transfer of Ownership.** Once the transaction is executed, the buyer transfers payment to the seller through a secure payment method such as a cryptocurrency. The smart contract verifies that the payment has been made and then transfers ownership of the NFT to the buyer.
4. **Traceability and Transparency.** The ownership of the NFT is recorded on a blockchain-based ledger, providing a transparent and traceable record of ownership. The owner can also transfer the NFT to a new owner by selling it on a marketplace or auction, and the ownership transfer is also recorded on the blockchain.
5. **Prevention of Illicit Financing.** If the artwork was purchased with illegally obtained funds, law enforcement can trace the ownership of the NFT on the blockchain and potentially seize the asset. This creates a disincentive for criminals to use art as a vehicle for illicit financing.

Yaya J. Fanusie, Former CIA, CNAS Senior Fellow commented: "NFTs play a major role in upholding authenticity and securing and transmitting ownership history, which is critical for anti-money laundering processes".

Overall, this process provides a secure and transparent way to tokenize and trade art, reducing the risk of fraud and other illicit activities. By using NFTs and tokenization, the art market and others can become more accessible, efficient, and trustworthy for both buyers and sellers.

7.3.3. Ecosystem/Biodiversity Tokens for Carbon Offsets

Tokens can aim to create a decentralized marketplace for nature-based solutions to climate change. The use-case will be a platform where environmental assets such as carbon credits, biodiversity offsets, and ecosystem services can be tokenized and traded. Creating tokens to represent environmental costs can be used by the art world and the financial services. A cost-benefit approach can be used to protect/ invest, and ultimately put our ecosystems on a sustainable path.

Rebalance Earth⁶⁸ is leading by example by creating Eco Tokens⁶⁹ that increase the transparency of the environmental externalities of elephant sequestration. These tokens represent living elephants, can be purchased by companies, individuals, or governments, and can be tracked throughout an enterprise blockchain. Elephants increase carbon capture levels,⁷⁰ and these tokens enable this process by having an open market sale of carbon off-setting tokens which can be tracked and traced.

If we can reliably identify and measure the market-value services provided by natural resources, we can then compare the present monetary value of these benefits with the cost of investing in them, just as we do for other assets.

Anca Bogdana Rusu, Head of Public Sector at cLabs, provided examples of use cases for biodiversity tokens: “This [biodiversity tokenization] can be applied to different industries. One example is beef cattle raising in Argentina, an economy that depends on beef exports. If the water is polluted or there is no grass, their entire business is destroyed. Digital assets are financial instruments that can create incentives to maintain ecosystems and biodiversity. Then, in a couple years, if more crises impact a business supply chain, they can ensure access through tokenization.”

Anca Bogdana Rusu stated that the conversation about tokenization is focused on transparency, but the tokenization of ecosystem and biodiversity is equally as interesting. As an example regarding coffee production in Brazil, she remarked, “imagine a pitch to Starbucks or the government of Brazil to say you can tokenize biodiversity anywhere from the type of grass to insects to birds etc.” As she mentioned, tokenization opens a pathway to correct market failures that are taking a toll on biodiversity: *“This is internalizing the externalities that are caused by climate change, and the existence of these companies. They need to play a role in maintaining their ecosystem”*.

“You are looking at composing an index that tracks variations of all these inputs. You put a monetary value on it, and then Starbucks purchases a number of tokens that are financially packaged to ensure that the ecosystem stays in place. If you know trees are going to die, you start planting them now. If soil will decrease, you buy more and ship it.” This speaks to the extent to which this technology can be used to track not only the current status but also predict and help correct for future use.

7.4. Energy Impact Reductions

The art community cares about its energy impact and has taken prescient steps that reflect the future sustainable use of digital assets. Switching from PoW to PoS consensus mechanisms, moving time and transportation-intensive operations on-chain, and engaging in energy system mindfulness helps reduce energy costs, time and transportation costs, and carbon footprints.

1. PoW to PoS transition.

⁶⁸ <https://www.rebalance.earth/mission>

⁶⁹ See appendix.

⁷⁰ IMF December 2020 report: How African Elephants Fight Climate Change: Biologists estimate- if population of African forest elephants returned to its former size and recovered their former range, carbon capture will increase by 13 metric tons (1 mt = 1,000 kg) per hectare (10,000 sq meters).

The NFT art world has completely transitioned from PoW to PoS⁷¹ reflecting a broader trend in many communities to reduce the energy cost of their operations. Pre-Merge, NFTs were very energy intensive. Each transaction was using over ~50 kilowatt-hours (kWh), which equates to the annual energy consumption of about 1.5-2 average U.S. households. Post-Merge, NFTs built on the Ethereum blockchain and other blockchains using PoS have obtained over **99.95% reduction in energy consumption**. Erik Jansson noted that “since Ethereum is now on PoS, the energy consumption has been minute and immeasurable.” Innovation naturally follows more energy-efficient methods, and we will continue to see a transition to more energy-efficient mechanisms.

2. Moving energy-intensive operations on-chain.

The blockchain improves efficiency both in process time, energy, and cost. Using blockchain to improve energy efficiency shows that a 1% energy efficiency gain is associated with a 5% reduction in operating expense.⁷² With massive auction houses like Sotheby’s and Christie’s that generate over \$15B in total sales and over 60 thousand luxury objects transported around the world each year,⁷³ 5% is hundreds of millions of dollars.

While blockchain use in the art world on its own has not been geared towards reducing energy consumption, it has de facto done so. Creating a global marketplace on the energy-efficient Ethereum platform to transact art globally and verify smart contracts will reduce energy impact in transportation, authentication, and verification.

The art auction houses’ use of external experts to move on-chain has increased their efficiency, enhanced their client reach, and driven their revenue. This presents a model for the development of future technologies to solve unique problems that aim to reduce energy impacts.

3. Energy System Mindfulness.

Pre “Merge”, NFT auction houses and artists were mindful of their impact on the energy system. They engaged in practices to address the high energy usage of PoW that can be used by any business still using that consensus mechanism. Four steps they took to be mindful of their energy impact were:

- Waiting to release projects - lessening the burden on grid systems
- Making donations or purchasing carbon offsets
- Releasing projects on secondary blockchains - those with limited reach⁷⁴
- Using sustainable practices in other areas of business (powering buildings, packaging & shipping practices, etc.)

In the long-term, these habits adopted by the NFT community pre-Merge have created a more conscious community through good practices. Donations have now become a norm, other chains and layer 2s are adopting PoS and providing a healthy competition to Ethereum, and the community has become even stronger, more active, and can innovate their way in and out of situations through creative and workable ideas.

⁷¹ According to Open-Sea, the largest NFT marketplace by trade volume, most NFT transactions occur on the Ethereum blockchain, using the Ethereum cryptocurrency.

⁷² Amy Henry, CEO and Co-Founder of Eunike Ventures, a company that uses blockchain to improve energy efficiency.

⁷³ Senior expert in art auction house world

⁷⁴ Ariel Hudes, Head of Pace Verso, Web3 Project Gallery.

Christie's has made a commitment to energy usage "to be net zero by 2030,"⁷⁵ and Sotheby's has "committed to reducing its carbon footprint by at least 50% by 2030."⁷⁶ A lot of the sustainability strategy is related to things apart from digital assets such as powering buildings, reducing printing, and improving shipping practices.

7.5. Conclusion

Centralized art auction houses have been pioneers in embracing the use of decentralized digital assets and exploring the future of tokenization, blockchain development, carbon offsets, and security. They are paving the way for the responsible development of digital assets to reduce the environmental impact of their operations and promote sustainable practices, all while providing tangible benefits to their business processes. While digital assets are still in their nascency, this art auction house case study shows that these assets can be leveraged to reduce energy impact, increase market competitiveness, and transform the space. NFTs provide a new way for artists and creators to monetize their work, while tokenization has the potential to revolutionize the way we invest in assets.

7.6. Recommendations

NFTs and digital assets are an asset class. We are just now beginning to see meaningful adoption, and are poised to see this accelerate dramatically in the coming years, especially as the digital-first Gen Z comes into power.

Breakthroughs in technology and validation by the market have fueled the start, but there are still technological and regulatory hurdles ahead. Mainstream adoption will rely on technological advancements in usability, scalability, adaptability, and seamless integration into current systems. In addition, the space needs a regulatory framework to create security for businesses and customers. **The art auction houses show that it is possible to work around a less regulated field by creating your own industry standards and working with industry leaders.**⁷⁷ However, with billions of dollars at stake, security is paramount; therefore, until industry leaders emerge, it is wise to proceed cautiously and hedge your bets.

This will be a disruptive technology, and this shift towards digital assets presents an opportunity for value creation. **The art auction world has shown how these decentralized assets can be leveraged to increase revenue, deepen client engagement, streamline business operations, enhance security, and reduce energy impact.** Innovative use-cases, like authentication and provenance tokens, blockchain trackability, biodiversity tokens, and zero-knowledge proofs, digital assets can revolutionize our business processes, security landscape, and energy impact. The open nature of the network enables transparency and traceability and has untapped potential and usability in various industries.

⁷⁵ Erik Jansson, CIO at Christie's.

⁷⁶ Senior expert in the art auction house world

⁷⁷ See: Christie's x OpenSea; Christie's and Chainalysis; Sotheby's and Coinbase;

As these technologies continue to develop, it is important for investors and creators to be aware of the risks and challenges associated with them, including issues such as copyright/ownership, scalability, and regulatory concerns. **Moving forward, it is imperative that we approach the future of money with a compass that emphasizes transparency, security, and responsible innovation.** By prioritizing these values, digital assets will continue to evolve, expand, and provide utility for the world.

8. Final Remarks and Concluding Thoughts

Overall, the future of money is likely to be increasingly digital and decentralized, with new forms of digital assets emerging and evolving over time. For the future of money to be equitable and fair, nations need to take a thoughtful and responsible approach to these technologies. However, the future of money is fractured between authoritarian countries and non-authoritarian use of finance and digital assets.

Blockchain technology is here to stay and, currently, the EU is far ahead of the United States. The EU lawmakers recently approved the world's first comprehensive framework for crypto regulation. Additionally, many other nations, including the EU, are making significant progress in developing CBDCs.

The world is entering an environment of a basket of currencies. The U.S. is falling behind in the digital asset space especially in CBDC innovation and development. This may end up hurting U.S. 's and the dollar's global competitiveness especially if other nations including allies develop interoperable CBDCs and use it for trading.

We have learnt through history that the traditional banking systems are not dependable during crisis situations, when financial needs are the highest and the potential for fraud also increases. Blockchain and digital assets can provide a safe haven and security for transferring funds directly and immediately from the source to the recipients without intermediaries and settlement time. The U.S. needs to create a comprehensive regulatory framework for this space, addressing both financial and climate concerns, in order to reap the real benefits of digital assets in a safe and secure manner for its citizens and to maintain its leadership in the global economy. The U.S. government needs to heavily invest in education and expertise development in this space, especially for regulators and policymakers, to make decisions based on complete and accurate information.

The energy narrative is still split in the U.S. and a deeper research and investigation is needed, preferably commissioned at the federal level, to understand the full extent of energy usage and sources. However, the larger issue is to understand the value of Bitcoin specifically and justify its energy use, particularly in Bitcoin mining operations.

First and foremost, a broader narrative of digital assets needs to be understood by the U.S. government, and then the current system used to regulate the traditional financial system will need to change. A new or a more comprehensive system should be created to incorporate these new financial tools and assets.

However, the decentralization of cryptocurrencies and the open marketplaces on blockchain that give back control to the users, creators and holders of the assets should not be ignored and nor should it be curbed. The democratization of the economy is happening via blockchain technology, and we are currently in a new era of economic growth and global influence along with an opportunity for rapid innovation.

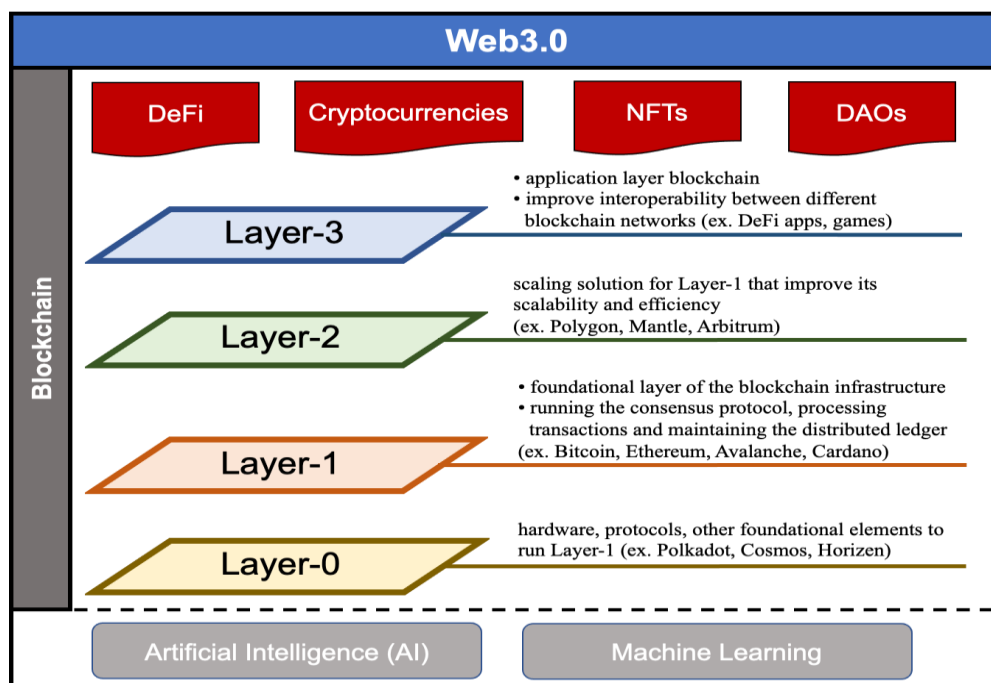
Without strong reasoning backed by extensive research and analysis to ban, curb, or minimize digital assets, including crypto currencies, and their influence on our financial systems and climate, the U.S. government will be left behind as the naysayers while this space takes off along with catapulting other nations into the forefront of technological innovation and financial transformation.

9. Appendix

○ Annex 1 – Decentralized Finance & Cryptocurrencies

Web3.0, Blockchain and DeFi

In Web3.0, the crypto assets users have more control over the content and are rewarded through the crypto assets transactions and other financial services in nature. Web3.0 is the next generation of the world wide web using blockchain technology and artificial intelligence. Blockchain has mainly four layers which play different roles to support peer-to-peer transactions. Layer-0 is an infrastructure underlying Layer-1 and serves to back up transaction data from various Layer-1. Layer-1 is the main infrastructure that is responsible for running the consensus protocol, processing transactions and maintaining the distributed ledger. Layer-2 is a scaling solution for Layer-1 blockchains that improves scalability and efficiency in Layer-1. These blockchains play a key role in enabling the operation of DeFi and cryptocurrencies transactions. Layer-3 is an application layer that improves interoperability among blockchain network services. These blockchain layers build decentralized transactions with cryptocurrencies and NFTs and offer services such as DeFi and gaming.



Development of Bitcoin-based DeFi

The Bitcoin network does not have smart contracts and Bitcoins holders had to convert their Bitcoin into wrapped versions on other blockchains or wBTC assets to participate in other DeFi protocols such as Ethereum. The Bitcoin network was updated in November 2021 for improving scalability, privacy and efficiency, called "Taproot update". It was the first time since the Segwit update in 2017.

Scalability. In the Bitcoin network, the transactions should have been verified individually by validating digital signature. After the Taproot update, it allows multiple signatures and transactions to be batched together, which help to increase the speed of transaction.

Privacy. There becomes less distinction between single and multi-signature transactions which makes it difficult to identify each user's transaction inputs.

Efficiency. It allows the hosting of smart contracts without barriers of multiple signatories and complex transactions.

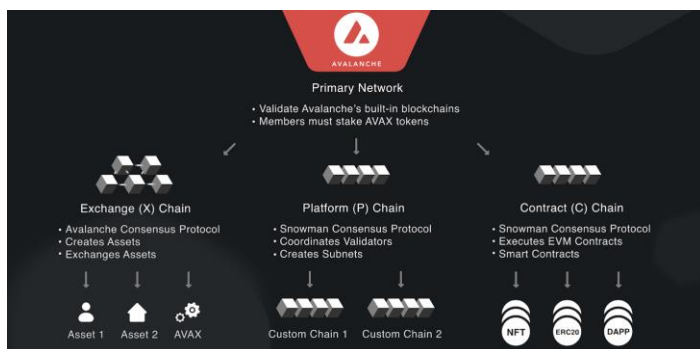
Avalanche (AVEX)

Avalanche was launched in 2020 by Ava Labs and became popular as an extremely efficient blockchain and open-source platform for building apps. Avalanche is designed to solve blockchain trilemma in terms of scalability, decentralization, and security by having heterogeneous network blockchains: Exchange (X) chain, Contract (C) chain, and Platform (P) chain.

- X-chain supports the creation and transaction of digital smart assets including AVEX. It uses the Avalanche consensus mechanism in which validating node arbitrarily selects a small group of other validators to make an accepted or rejected decision until attaining a sufficient confidence threshold. It promotes scalability with high throughput. It is also designed to be interoperable with other subnets within the Avalanche network.
- C-chain is designed for creating and managing smart contracts and dApps. It supports the Ethereum Virtual Mechanism (EVM), which allows developers to port their existing Ethereum dApps to the Avalanche network without having to rewrite their code. This chain hosts Avalanche's DeFi ecosystem.
- P-chain allows users to build new subnets which can be customized blockchains with the main Avalanche network.

Avalanche Network⁷⁸

Avalanche Consensus⁷⁹



| Consensus: Classical vs Nakamoto vs Avalanche | | | |
|---|-----------|----------|-----------|
| | Classical | Nakamoto | Avalanche |
| Scalable | - | + | + |
| Robust | - | + | + |
| Highly Decentralized | - | + | + |
| Low Latency | + | - | + |
| High Throughput | + | - | + |
| Lightweight | + | - | + |
| Green, Sustainable | + | - | + |
| Resilient to 51% Attacks | - | - | + |

⁷⁸ Avalanche. (2023). *Avalanche Platform*. <https://docs.avax.network/overview/getting-started/avalanche-platform#platform-chain-p-chain>

⁷⁹ Avalanche. (2023). *Consensus*. <https://docs.avax.network/overview/getting-started/avalanche-consensus>

Carbon Footprint and Market Capitalization of Cryptocurrencies and Tokens (updated in 4.3.2023)

| Cryptocurrencies | Blockchain Layer | Consensus Mechanism | Market Cap (\$) | Electrical Power (MW) | Electricity Consumption (annualized) (TWh) | CO2 Emission (annualized) (Mt) |
|------------------|------------------|---------------------|-----------------|-----------------------|--|--------------------------------|
| Bitcoin | Layer-1 | PoW | 535,904,472,789 | 15930 | 139.62 | 84.37 |
| Ethereum | Layer-1 | PoS | 213,525,752,176 | 0.33 | 2.87 | 0.96 |
| Cardano | Layer-1 | PoS | 13,164,832,715 | 0.07 | 0.63 | 0.29 |
| Dogecoin | Layer-2 | PoW | 10,762,652,032 | 190 | 1.68 | 1.02 |
| Polygon | Layer-2 | PoS | 9,828,291,038 | 0.01 | 0.11 | 0.05 |
| Solana | Layer-1 | PoS | 7,774,747,079 | 0.64 | 5.60 | 2.57 |
| Polkadot | Layer-0 | PoS | 7,494,178,173 | 0.01 | 0.07 | 0.03 |
| Litecoin | Layer-2 | PoW | 6,664,572,570 | 120 | 1.06 | 0.64 |
| TRON | Layer-1 | PoS | 5,898,678,150 | 0.02 | 0.17 | 0.08 |
| Avalanche | Layer-1 | PoS | 5,521,686,302 | 0.06 | 0.54 | 0.25 |

Source: CCRI Crypto Sustainability Indices, [https://indices.carbon-ratings.com/?](https://indices.carbon-ratings.com/)

Regulations on Crypto Assets

[Energy Regulation or Executive Order]

| | | |
|------|----------|---|
| U.S. | 03.09.22 | the Executive Order on Ensuring Responsible Development of Digital Assets |
| | | <ul style="list-style-type: none"> • The first whole-government approach to recognize the potential benefits and risks of digital assets. • EO mandated federal agencies to report on digital assets and their role in the financial system. • Key policy objectives: (1) protecting U.S. consumers, investors, and businesses; (2) preserving the stability of the U.S. and global financial systems; (3) preventing illicit finance and national security risks; (4) reinforcing U.S. leadership in the global financial system and technological competitiveness; (5) promoting access to safe and affordable financial services; and (6) promoting responsible technological development.⁸⁰ |
| | | the Crypto-Asset Environmental Transparency Act |
| | 12.07.22 | <ul style="list-style-type: none"> • Senator Jeff Merkley proposed to instruct the Environmental Protection Agency (EPA) to report on crypto mining activity consuming more than 5 MW. • U.S. lawmakers pointed out that Bitcoin mining accounted for roughly 1.4% of the electricity consumption in the U.S.⁸¹. |
| | 03.06.23 | <ul style="list-style-type: none"> • Senator Merkley reintroduced the Act to study the environmental and grid impacts of cryptocurrency mining methods⁸². |

⁸⁰ The White House. (March 2022). *Executive order on ensuring responsible development of digital assets*, <https://www.whitehouse.gov/briefing-room/presidential-actions/2022/03/09/executive-order-on-ensuring-responsible-development-of-digital-assets/>

⁸¹ GPO. (December 2022), *117th Congress: S5210*. <https://www.congress.gov/117/bills/s5210/BILLS-117s5210is.pdf>

⁸² GPO. (March 2023). *118th Congress: S661*. <https://www.congress.gov/118/bills/s661/BILLS-118s661is.pdf>

| | | |
|----|----------|---|
| EU | 10.18.22 | Action Plan to Digitalizing the Energy System - Commission presented |
| | | <ul style="list-style-type: none"> Objective: boost digital energy service while ensuring energy efficiency in the ICT sector including blockchain technologies. The Commission will urge Member States to implement policies lowering electricity consumption of crypto-asset miners. The Commission plans to introduce tax breaks and other fiscal measures benefiting crypto-miners currently in force in certain Member States in the end. On the other hand, the Commission will urge the Member States to stop crypto-assets mining in case there is a need for load shedding in the electricity systems⁸³. |
| | 04.20.23 | Markets in Crypto-Assets (MiCA) - European parliament approved |
| | | <ul style="list-style-type: none"> Issuers of all types of crypto-assets must issue white papers (prospectus for crypto-assets), informing potential holders of the crypto-asset, crypto-asset project or tokens, risks, the rights and obligations attached to the crypto-asset and adverse environmental impacts of consensus mechanism⁸⁴. The MiCA does not capture DeFi since the crypto-asset services that "are provided in fully decentralized manner without any intermediary" and crypto-assets without an identifiable issuer do not fall within the scope of MiCA. |

[Timeline of U.S. Regulators Charging Crypto Firms & Dealing with DeFi]

| | |
|----------|--|
| 01.03.23 | FED, OCC and FDIC issued "Joint Statement on Liquidity Risks to Banking Organization Resulting from Crypto-Asset Market Vulnerabilities" |
| | The statement noted that "certain sources of funding from crypto-asset-related entities may pose heightened liquidity risks to banking organization due to the unpredictability of the scale and timing of deposit inflows and outflows" |
| 01.31.23 | FED banned state banks from holding crypto-asset as principal |
| 02.09.23 | Kraken agreed to seize U.S. crypto-staking operations to settle SEC charges |
| | <ul style="list-style-type: none"> Kraken (crypto exchange) failed to register the service under securities law Kraken paid \$30 million and cease offering staking services to U.S. customers |
| 02.13.23 | SEC sent Paxos (BUSD issuer) Wells Notice to stop minting BUSD |
| | <ul style="list-style-type: none"> BUSD was an unregistered security. Paxos will halt minting new BUSD tokens in 2024. |

⁸³ EC. (October 2022). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions: Digitalising the energy system - EU action plan*. EUR Lex. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0552&qid=1666369684560>

⁸⁴ Council of European Union. (October 2022). *Proposal for a Regulation of the European Parliament and of the Council on Markets in Crypto-assets, and amending Directive (EU) 2019/1937 (MiCA)*, <https://data.consilium.europa.eu/doc/document/ST-13198-2022-INIT/en/pdf>

| | |
|----------|--|
| 03.22.23 | SEC sent Coinbase, Inc. (crypto exchange) Wells Notice warning that the SEC has identifies possible violation of securities law from staking service |
| 04.06.23 | U.S. Department of Treasury released DeFi Illicit Finance Risk Assessment |
| 04.14.23 | SEC voted 3-2 to expand security regulation to include the DeFi technology underlying cryptocurrency |

[Crypto-mining Regulation after the crypto ban in China]

| Regulation | | | |
|---------------|-------------------------------|---------------------------|---|
| Country/State | Introduction (Effective) Date | Bill | Detail |
| U.S. | New York | Jun.22.2022 (Nov.23.2022) | Bill S6486D <ul style="list-style-type: none"> • a two-year moratorium on mining operations that use PoW or operations shall be subject to full environmental impact statement review • stop new fossil-fueled crypto mining operations within two years • pause renewal of licenses for existing operations in the state • any new PoW mining operation in the state could only operate if it uses 100% renewable energy |
| | Texas | Mar.23.2023 | Senate Bill <ul style="list-style-type: none"> • eliminate the incentives and subsidies put in place to attract crypto-mining • bar virtual currency mining from tax abatements given that the large scale of growth in existing virtual currency mining |
| | Department of Treasury | Mar.23.2023 | Administration's Fiscal Year 2024 Revenue Proposals <ul style="list-style-type: none"> • 30% excise tax on the cost of electricity used in digital asset mining • facilities required to report the amount and type of electricity used and value of that electricity • excise tax would be phased in over 3 years (10% in 2024, 20% in 2025, 30% in 2026) |
| Sweden | (July.2022) | - | <ul style="list-style-type: none"> • Eliminate 98% tax reduction policy for data centers and crypto mining businesses – data centers are subject to the same electricity tax rates as other industries • Power tax increases from \$0.0006 to 0.035 per kWh |
| Norway | Oct.6.2022 (Jan.1.2023) | - | <ul style="list-style-type: none"> • Eliminate smaller electricity tax rates for data centers and crypto mining businesses; in the Nordic country – data centers are subject to the same electricity tax rates as other industries • Power tax increased from \$0.0086 to \$0.015 per kWh |
| Kazakhstan | Feb.8.2022 | | Tokarev ordered a cabinet-level investigation of cryptocurrency mining |

| | May.2022 | | <p>Minister of Digital Development compels digital mining business to provide comprehensive information 30 days before starting operations</p> <p>Information: electricity consumption, technical specifications for connection to power grid, amount and type of mining equipment used, customs cargo declaration, investments planned for the next 12 months, legal entity carrying out the operation (must be resident of the Kazak), IP addresses, contact information, quarterly report</p> | | | | | | | | | | |
|------------------------------|-----------------------------|---|---|-----------------------------|-------------------|-----------------------------|-------------|------------------------------|------------|------------------------------|------------|-------------------------|-----------|
| | Jun.29.2021 (Jan.1.2023) | Amendment to the national tax code | <ul style="list-style-type: none"> Graded tax rates tied to the electricity prices consumed by mining entities The levies will be determined based on the average price of the electricity consumed to mint coins during a certain tax period. <table border="1"> <thead> <tr> <th>Electricity price (per kWh)</th> <th>Additional burden</th> </tr> </thead> <tbody> <tr> <td>5-10 tenges (\$0.012-0.024)</td> <td>+ 10 tenges</td> </tr> <tr> <td>10-15 tenges (\$0.024-0.036)</td> <td>+ 7 tenges</td> </tr> <tr> <td>20-25 tenges (\$0.048-0.060)</td> <td>+ 3 tenges</td> </tr> <tr> <td>Using renewable sources</td> <td>+ 1 tenge</td> </tr> </tbody> </table> | Electricity price (per kWh) | Additional burden | 5-10 tenges (\$0.012-0.024) | + 10 tenges | 10-15 tenges (\$0.024-0.036) | + 7 tenges | 20-25 tenges (\$0.048-0.060) | + 3 tenges | Using renewable sources | + 1 tenge |
| Electricity price (per kWh) | Additional burden | | | | | | | | | | | | |
| 5-10 tenges (\$0.012-0.024) | + 10 tenges | | | | | | | | | | | | |
| 10-15 tenges (\$0.024-0.036) | + 7 tenges | | | | | | | | | | | | |
| 20-25 tenges (\$0.048-0.060) | + 3 tenges | | | | | | | | | | | | |
| Using renewable sources | + 1 tenge | | | | | | | | | | | | |
| | Feb.6.2023 | Tokayev signed law against unlawful mining operations and issuance of crypto assets | <ul style="list-style-type: none"> Digital asset issuers will be subject to monitoring by “On Combating the Legalization of Proceeds from Crime and the Financing of Terrorism” (enter into force from 04.01.2023) Crypt miners in Kazak will be forced to sell at least 75% of their revenue via registered crypto exchanges (effective from 01.01.2024) Crypto mining licenses in Kazak are issued for a limited period of 3 years (difference based on whether the miner owns the mining facilities or not) | | | | | | | | | | |

Deregulation / Protection

| | | | | |
|------|-------------|------------------------------|--------------------------------------|---|
| U.S. | Kentucky | Mar.21.2023 (Jul.22.2023) | House Bill 230 | remove sales tax from electricity purchased by local crypto-mining operators |
| | Georgia | Feb.22.2023 | House Bill 1342 | <ul style="list-style-type: none"> exempt sale or use of electricity used in commercial mining of digital assets only apply to commercial miners operating in a facility of at least 75,000ft² |
| | Montana | Feb.23.2023 | Senate Bill 178 | <ul style="list-style-type: none"> prohibit discriminatory digital asset mining utility rates protect miners against taxes on digital assets used as a means of payment permit home crypto miners who use less than 1 MW of energy annually except when in contravention of existing noise by laws prohibit zoning restrictions that target cryptocurrency miners |
| | Mississippi | Feb.23.2023 (Jul.23.2023) | Mississippi Digital Asset Mining Act | <ul style="list-style-type: none"> prohibits limiting noise from home mining beyond existing limits, imposing requirements on miners beyond |

| | | | | |
|--|----------|-------------|-------------------------------------|--|
| | | | | <p>those locally applied to data centers, or changing the zoning of a mining center without proper notification and an opportunity to appeal</p> <ul style="list-style-type: none"> ● prohibits imposing discriminatory electricity rates on mining business ● exempt home and business miners from money transmitters |
| | Missouri | Mar.7.2023 | Digital Asset Mining Protection Act | prevent energy companies from applying discriminatory tax rules to mining corporations |
| | Arkansas | Apr.20.2023 | Arkansas Data Centers Act of 2023 | protect Bitcoin miners from discriminatory regulations and taxes, guaranteeing that firms have the same rights as data centers |

Background related to Case-study

[Crypto-mining environment in Kazakhstan]

Since China's crypto ban in 2021, more than 87,849 crypto-mining machines have been relocated to Kazakhstan where cheap fossil fuel-based electricity is abundant. Kazakhstan is the second largest Bitcoin mining hub in the world with 18.1% of hash rate⁸⁵.

[Crypto-mining environment in Norway]

Norway has the largest Bitcoin mining hub in Europe with 0.74% Bitcoin hash rate⁸⁶. The country's 92% of hydropower-based electricity production and cold climate is ideal for mining activities⁸⁷. Data centers and crypto-mining were previously exempt from grid rent and subject to reduced power tax rates for using hydropower. However, in October 2022, the Norwegian government scrapped the tax incentives for data centers and crypto-mining to promote distribution of renewable power to the community and prevent electricity price hikes in Norway.

[Singapore Exchange Limited (SGX)]

Singapore Exchange Limited (SGX) is an investment holding company that provides securities and derivatives trading services throughout Asia. They operate under strict regulatory standards and use technology to transform the financial market infrastructure. SGX provides markets for equities, fixed income, and derivatives, and strives for innovation to keep up with the changing needs of investors.

SGX was reliant on heavy data-center infrastructure and complex transaction workflows. Batch processing and manual reconciliation still plagued most types of financial transactions, and compounded by localized infrastructure, hampered the growth and innovation SGX required to keep pace with the rapidly changing needs of investors. Financial institutions continue to rely heavily on data centers, which often lead to overbuilt networks and

⁸⁵ CBECI. (April 2023). *Bitcoin mining Map*. https://ccaf.io/cbeci/mining_map

⁸⁶ CBECI. (April 2023). *Bitcoin mining Map*. https://ccaf.io/cbeci/mining_map

⁸⁷ IEA. (2022). *Norway 2022: Executive summary*. <https://www.iea.org/reports/norway-2022/executive-summary>

infrastructures that operate at low efficiency, despite the advancements in e-commerce ecosystems. The need for secure and mission-critical environments over the years has contributed to this situation.

○ **Annex 2 – Stablecoins’ Background and Regulation**

Background:

Stablecoins are a type of crypto currency “pegged” to an external reference or physical asset such as the U.S. dollar, Euro, or gold, which differentiates them from the potential more volatility of traditional crypto currency. They are used as both a means of payment and store of value.

Stablecoins’ perceived stability contributed to their rapid rise in popularity from 2021 onward. However, in the past year, they have been the object of enforcement and regulation due to high-profile failures causing authorities and stakeholders in the industry to question the suitability of the term, which has even been questioned by some of the leading actors in the industry, i.e. Circle Chief Strategy Officer and Head of Global Policy Dante Disparte mentioned in one of our industry expert interviews that the issuer or USDC rejects the term “stablecoin” and rather envisions their product as a “dollar referenced currency”.

Stablecoins maintain their tie to real world assets through “stabilization mechanisms.” There are several types of stabilization mechanisms: off-chain collateralized, on-chain collateralized, and algorithmic, each with its own degree of risk that the “peg” could be broken.” Algorithmic coins, for example, are actually not backed by real-world assets, but based on an algorithm that attempts to regulate the peg by burning and/or minting coins to stabilize supply and demand.

Stablecoin TRUST Act:

- On December 21, 2022, outgoing Senator Pat Toomey (R-PA) introduced the Stablecoin TRUST Act of 2022, which aims to establish the first-ever federal regulatory framework for payment stablecoins. Payment stablecoins are defined as a digital asset that is designed to maintain a stable value relative to a fiat currency, is convertible directly to fiat currency by an issuer, is widely used as a medium of exchange, is issued by a centralized entity, does not inherently pay interest to the holder, and is recorded on a public cryptographically secure distributed ledger.
- Payment stablecoins would be regulated by the Office of the Comptroller of the Currency (OCC) and create a new federal license issued by the OCC, specifically for payment stablecoin issuers, that would then be referred to as "National Limited Payment Stablecoin Issuers." Payment stablecoin issuers would include depository institutions, state-based money transmitting businesses, non-depository trust companies, entities authorized by state banking supervisors, and national trust banks.
- All payment stablecoin issuers would be required to fully back their payment stablecoins with high-quality liquid assets and establish new, standardized public disclosure requirements for all payment stablecoin issuers. It would

also allow depository institutions to separate payment stablecoin issuance from other activities and receive equitable and tailored regulatory treatment.

- According to this bill, payment stablecoins are not securities and payment stablecoin issuers are not investment companies or investment advisers, taking such issuers out of the jurisdiction of both the SEC and the CFTC. It would also apply existing privacy and data security requirements to payment stablecoin issuers, reject the notion that existing Bank Secrecy Act reporting requirements should be applied to payment stablecoins, and clarify that private transactions, not involving an intermediary or a financial institution, do not need to be reported.
- Consumers would be protected by clarifying that payment stablecoin holders would have priority in the event of an issuer's insolvency. The legislation will not affect non-payment stablecoins, such as stablecoins backed by commodities or other digital assets, or algorithmic stablecoins. State banking supervisors are permitted to impose additional or stricter regulatory standards on state-licensed payment stablecoin issuers and insured depository institutions may accept or receive deposits and issue digital assets that represent deposits.
- It is important to note that Senator Toomey retired at the end of the congressional session, on January 3, 2023, and was replaced by Tim Scott (R-SC) as the Senate Banking Committee's Ranking Member, whose views on stablecoins have yet to be publicized.

Hearing: Understanding Stablecoins' Role in Payments and the Need for Legislation (April 19th, 2023)

Delicia Reynolds Hand, Director, Financial Fairness, Consumer Reports:

- The lack of a uniform and meaningful regulatory framework for stablecoins in the U.S. could create significant risks for consumers, including an unlimited supply of tokens and coins serving as collateral for loans, rigid self-executing smart contracts, and non-existent reserve requirements. Stablecoins, which are designed to maintain a stable value, have grown in popularity over recent years, but their volatility has been demonstrated with the introduction of algorithmic stablecoins and the collapse of Terra and Celsius. Despite this, stablecoins continue to be used for payments and facilitate trade between fiat currency and other crypto-assets or between different crypto assets, with more than 75% of trading on large crypto exchanges involving a stablecoin on one or both sides of the trade.
- Consumer Reports has urged the committee to develop common sense legislation to effectively regulate stablecoins, taking into account responsible innovation, financial stability, and financial inclusion. The organization emphasizes the need for appropriate regulation, supervision, and oversight to be implemented before stablecoins become a risk to financial stability and the smooth functioning of payment systems. While the draft bill introduces some prudential standards into the regulation of the issuance and trading of payment stablecoins, Consumer Reports suggests that more comprehensive regulatory oversight, at least parallel to existing guardrails in consumer protections in the prudential system, is needed due to the continued instability and broader ecosystem. The organization urges lawmakers to create a regulatory framework for stablecoin payments that reflects learnings from recent events.

- Ms. Reynolds raised concerns about the current regulatory process for stablecoin payments and suggested ways in which the proposed bill can be improved to ensure consumer protection, financial stability, and effective regulation. She argued that the bill fails to adequately address issues related to regulatory oversight and arbitrage, risk management infrastructure, insurance for stablecoin issuers, and administrative processes. Additionally, she suggests that the bill should include specific key requirements for stablecoin payments that parallel the requirements for traditional banking and that the law should be the same across all 50 states and emphasizes the need for the FSOC to have a clear role in regulating stablecoin payments given the high-risk nature of this space.
- The bill should include requirements for payment activities conducted by issuers of payment stablecoins to have adequate consumer protections, including the ability to reverse transactions for chargebacks or payment disputes. Ms. Reynolds advocates for stablecoin payment regulation to be technology-neutral and interoperable. Additionally, she recommends improvements to the language associated with custodial wallets, stronger consumer and investor protections, clearer guidelines for redemptions and increased activity limitations, and prohibiting certain convicted individuals from participating in stablecoin payments. Finally, the Federal Reserve Board's authority over stablecoin payment issues should be prioritized over prudential regulators and consumer protection regulators.
- She discusses the absence of explicit recognition, consultation, or authority for the SEC in the proposed stablecoin regulation bill, and argues that this is a significant omission, given the SEC's active role in this space and the number of interventions it has brought on behalf of consumers. She suggests that the bill needs more explicit clarity on how and when the SEC can and should regulate stablecoins, particularly when they function like investment products or are traded on secondary markets. Ms. Reynolds urged the committee to include a new consultation provision with the SEC regarding registration, disclosure, and investor protection, to ensure comprehensive oversight of stablecoin payments that prioritizes consumers. Without such clarity, she warns, the bill will create additional regulatory uncertainties and could lead to future boom and bust cycles.

Dante Disparte, Chief Strategy Officer and Head of Policy for Circle:

- Over the course of Circle's 10 years of activity, the company has always aspired to a regulation-first approach based on trust, transparency, accountability and financial integrity. The first USDC was issued five years ago, and since then, USDC has supported more than \$10 trillion in cumulative transactions on the public internet. USDC-enabled wallets support a global payment network in more than 190 countries, which is akin to a mobile money network like M-Pesa, but on a world scale.
- More than 75% of all USDC in circulation are held in digital wallets and smart contracts rather than on digital asset exchanges, suggesting a strong correlation as a dollar-denominated store of value. Indeed, USDC's programmable, composable, trusted, and open nature has led to a Cambrian explosion of use cases and responsible innovation. Rather than disrupting traditional financial systems or markets, USDC is seeing growing acceptance as a dollar settlement option among major financial services firms from Visa to MoneyGram, among many others.

- Mr. Disparte highlighted the need for U.S. policymakers to take action regarding stablecoins, which have emerged as a significant risk in the crypto market, and there is a need for clear rules and regulations to ensure that the US dollar remains the leading digital currency of the internet. Also, the recent crypto market correction as evidence of the risks associated with emerging crypto asset markets, including algorithmic stablecoins. While policymakers and regulators have been warning about excess risk in the market, stablecoins were largely overlooked, despite warnings.
- The importance of regulation in the fintech industry was discussed, noting that electronic money and payments have been regulated under money services business and money transmission statutes for the past two decades. The U.S. Department of the Treasury introduced guidance for crypto assets nearly ten years ago, but there is now a need to update these regulations to account for the emergence of stablecoins and digital currencies. There is a geopolitical and geoeconomic issue at play with the adoption of digital currencies as an internet-native medium of exchange. As such, there is intense international competition to establish the dominant digital currency of the internet, and the U.S. has the opportunity to lead the way. Mr. Disparte suggested that Congress should act in a pro-innovation, bipartisan way to address stablecoin policy.
- Finally, he presented the Committee with Circle's Stablecoin Policy Principles:
 - To the right of lawful and consistent with democratic values, the use of money should be free, irrespective of its form factor.
 - A dollar digital currency (or payment stablecoin or digital cash) is a digital bearer instrument entitling the holder to redemption at par for one U.S. dollar, even in the event of the issuer's bankruptcy.
 - The presumption and preservation of privacy should be enshrined as a design principle in the issuance and circulation of dollar digital currencies.
 - Transparency, accountability and harmonized risk disclosures are essential preconditions of market trust and consumer protection.
 - The preservation of bank and non-bank dollar digital currency issuance promotes competition, a level playing field, and rules-based upgrades in the financial system. Bank-like risks should be addressed with scale-appropriate bank grade levels, including asset liability management, operational and enterprise risk management considerations.
 - Dollar digital currency innovations are about optionality in the payments and banking system and not substitution. As such, their harmonized regulation and promotion should expand new forms of financial access through composable and programmable digital currency innovations, while promoting safe integration with existing systems of electronic money and financial markets infrastructure.
 - The promotion of interoperability, fungibility and universal exchange of comparably regulated and reserved dollar digital currencies among and between regulated intermediaries promotes competition, lowers barriers to entry and increases market choice. Stablecoin statutes should promote the development of supervisory, risk and operational frameworks for multiple issuers of the same stablecoin standard.

- The promotion of financial equity, inclusion and broader societal participation in lower cost payments, device-centric banking and trusted, always-on financial services can be a net benefit for historically marginalized communities. This must include a digital corollary to the Community Reinvestment Act (CRA), widening the net of participation to include community banks, minority depository institutions (MDIs) and credit unions in deposit taking, asset management and digital transformation efforts.
- The protection, application and collective defense of all applicable and appropriate financial integrity norms, including anti-money laundering (AML), countering the financing of terrorism (CFT), sanctions requirements and, know your customer (KYC) standards, should be universally applied. This should be done in ways that advance national and global security, while upholding democratic values and embracing new innovations in digital identity and credential verification that simultaneously preserve privacy while enhancing financial integrity.
- The application of safety, soundness and risk-adjusted prudential standards should be adopted, including in the strict adherence to cash and dollar-backed asset composition, maturity, weighting, liquidity and custody, including where appropriate, the promotion of direct custody at the Federal Reserve.
- Dollar digital currencies should be intermediated and responsive to monetary policy and its transmission, which is a sovereign activity that is conveyed through the intermediated, well-regulated and rules-based financial system designed to preserve global trust in the U.S. dollar. This includes applicable financial stability objectives, which should preclude dollar digital currency issuers from formulating monetary policy or calibration frameworks that may be in conflict with central banking and prudential regulatory norms.
- Dollar digital currencies provide different functionality from and can co-exist with central bank digital currencies (CBDCs). Policymaking should ensure an even playing field, robust competition and scalability, with careful consideration of technological and operational risk, while preserving the two-tier banking and payment system.
- As a digital bearer instrument, dollar digital currencies should at all times remain backed 1:1 by equivalent dollar-backed high quality and liquid assets in the care, custody and control of well-regulated financial institutions and banks in a bankruptcy-remote manner.
- Dollar digital currencies should promote responsible financial services innovation and trusted forms of always-on banking and payments through the use of open, internet-scale, constantly upgradable financial markets infrastructure. This combats technological obsolescence in financial infrastructure, improves cyber resilience and security and promotes domestic and global competitiveness through payment system optionality.
- Harmonizing national regulatory and policy frameworks for dollar digital currencies advances U.S. economic competitiveness, job creation and payment system optionality, while averting a harmful domestic “fintech constitutional crisis,” and global regulatory arbitrage. With the passage of Europe’s Markets in Crypto-Assets Framework (MiCA), which will be for crypto-assets what GDPR was to privacy, U.S.

leadership is needed to avoid trans-Atlantic or global misalignment, while harmonizing standards for payment stablecoins.

- The promotion, development and standardization of digital identity and credential verification standards are critical companion solutions for more inclusive, privacy-preserving dollar digital currency innovations that advance in lockstep with financial integrity.
- Public private partnerships that employ dollar digital currencies, open financial markets infrastructure, digital wallets, decentralized identity standards and related services can advance policy through practice and the provision of digital public goods - while upgrading national, open technological infrastructure.
- The promotion of fair market practices and the adoption of a “stablecoin Glass-Steagall Act” can help to guard against manipulative market conduct and concentration that could erode trust, trigger systemic risks and imperil market participants and consumers to financial loss.
- Dollar digital currencies should be treated as cash or cash-equivalents under U.S. and globally accepted accounting principles to promote clarity for market participants and consistency across international standard setting bodies. Such standardization will give households, firms and financial institutions confidence in integrating and using dollar digital currencies in everyday transactions.

Jake Chervinsky Chief Policy Officer of the Blockchain Association:

- The current financial system is dominated by a small number of large financial institutions that use slow, inefficient, and unreliable tools developed for the analog era. Public blockchains offer a revolutionary upgrade to the technology that powers the global financial system, providing faster, less expensive, more reliable, and inclusive payments infrastructure. Stablecoins, which maintain a stable value against a national currency like the U.S. dollar, represent a categorical improvement for global payments and provide the best mechanism to spread dollars far and wide, strengthening the dollar's dominance. Congress must pass tailored legislation to provide regulatory clarity to U.S.-based stablecoin issuers to maximize the benefits of U.S. dollar stablecoins. Five principles for effective stablecoin legislation are outlined to protect consumers while promoting innovation:
 - Different types of Stablecoins merit different types of regulation.
 - U.S. dollar stablecoins support the role of the U.S. dollar as global reserve currency.
 - The United States Should Support Stablecoins Instead of Creating a CBDC.
 - The SEC and CFTC Lack Authority to Comprehensively Regulate Stablecoins.
 - Congress Must Pass Stablecoin Legislation.

J. Austin Campbell Managing Partner, Zero Knowledge Consulting Adjunct Professor, Columbia Business School:

- Austin Campbell discussed the current state of stablecoins, which he believes has been chaotic, misinformed, and confusing for many people. He argued that stablecoins are not new and are essentially just cash instruments. He also explained that stablecoins can be a key to expanding the reach of the dollar, which is in high demand globally

due to the strength of the American economy and the solidity of the American legal system. By embracing stablecoins, the U.S. can expand the reach of the dollar into a new, rapidly growing market, which can help fund the government.

- Stablecoins can also be a key to financial inclusion. Opening a crypto wallet takes only thirty seconds and is faster than opening a bank account. This provides an option for people who have been mistreated by banks or who live in parts of the world where the official system is untrustworthy. Stablecoins can provide an immediate outlet for people who require only access to the internet and a phone to become their own bank vault and store stablecoins in that vault. In other words, stablecoins can be a tool to allow billions of people globally to adopt the dollar and the benefits that come with it, especially those with poor access to traditional financial services.
- The current situation in America is rapidly evolving into a ban on stablecoins. While some state regulators have attempted to blaze trails in the space, federal banking regulators have expressed concerns about issuing tokens on open, public, and/or decentralized networks, or similar systems. This has caused banks to back away from banking the crypto sector, making it difficult for stablecoin projects to establish basic banking relationships.
- On top of that, the SEC has sent a Wells Notice to Paxos, the issuer of BUSD, alleging that the stablecoin is a security. Someone attempting to launch or manage a stablecoin in the U.S. doesn't know if they can issue on a public blockchain, doesn't know if they can get banking relationships, and doesn't know if they have to answer to a state financial regulator, a federal banking regulator, or the SEC, who all often have mutually contradictory answers as to responsibilities. In the face of all this uncertainty, the market is moving outside of the United States. Governments and financial regulators in Singapore, the EU, Dubai, Abu Dhabi, Hong Kong, Bermuda, and others are beginning to provide regulatory clarity for stablecoins, which is attracting investors and entrepreneurs from around the world.
- Campbell argued that stablecoins are not the most important financial innovation of all time, nor are they a dire threat to the financial system. They are, in fact, a relatively mundane financial instrument that can help expand the reach of the dollar and provide financial inclusion for billions of people globally. However, the current regulatory uncertainty in the United States is causing stablecoin projects to move outside of the country, which could have significant long-term implications for the American economy and its global financial leadership.
- Finally, Mr. Campbell outlined a set of principles that should be enshrined in the bill proposal:
 - Stablecoins should have clear reserve guidelines that restrict the reserve assets to those which are appropriate for cash stability products. In particular, I would expand the assets permitted to cash and bank deposits, T-Bills, Agency Debt of less than 1 year maturity, Overnight Repo and Reverse Repo secured by treasuries or agency debt, and potentially small (<5%) holdings of certain highly rated types of municipal bonds. The overall portfolio should be limited to a weighted average maturity of 90 days or less. Government money market funds that fit within these guidelines should also be permissible assets.
 - Stablecoins should have a bankruptcy remote form factor for the reserves or strict guidelines around capital and controls, and thus, stablecoin issuers should either be insured depository institutions, uninsured

depository institutions, or trusts, and subject to appropriate regulatory oversight around their risk, capital, and controls. They should not be corporations without strict rules around these activities and they should not be able to operate using only money transmitter licenses, as those are insufficient for the protections needed for consumers and the financial system.

- Stablecoins should have a legal requirement to allow users to mint and burn coins at a stable \$1 peg, or if such a requirement cannot be fulfilled due to severe difficulties with the issuer, the ability to suspend redemptions and go into unwind or receivership under the supervision of an appropriate regulator (to avoid advantage or disadvantage specific token holders if such an event occurs). While small fees for mint and burn may be permissible, they should be limited in size and scope.
- Stablecoins should have appropriate controls around the mint/burn process to ensure their KYC/AML processes are on par with other regulated financial institutions, and stablecoins should only be allowed on blockchains that permit freeze and seize of stablecoins so that the tokens can be interdicted in the case of usage by criminals or other bad actors, either in response to legal orders or the stablecoin issuer's own risk policies and rules. Blockchain monitoring should also be required, as while blockchains operate pseudonymously, meaningful data analysis and tracking tools do exist and should be used to detect malicious activity and bad actors.
- Transparency should be mandatory, with stablecoins required to publish their entire reserve holdings no less frequently than monthly, publicly disclose the reserve guidelines that they are bound by so holders of the token are aware of what future reserve composition may look like, and to have audits or attestations (as appropriate) which include a review of these reports.
- Stablecoins with these features should be expressly permitted on public blockchains, as limiting them only to private blockchains or walled gardens ensures that they will not develop a network effect, will be captured by incumbent interests and will not benefit consumers, and likely have very significant privacy concerns that emerge about their usage.
- There should be rules around commercial speech that ensure only stablecoins that fit the guidelines laid out above are able to be called stablecoins. I can't just rent an office, buy a computer, and then start taking deposits and calling myself a bank without appropriate regulatory approval; stablecoins should be no different. A regulatory regime that expressly defines stablecoins and requires compliance with that regime would have prevented things like UST from catching on based on false promises of safety.
- Stablecoins should be allowed to pay interest to their holders, if and only if those holders have KYC'ed with the stablecoin issuer and their wallets are known, just like a bank account.
- It should be made clear that stablecoins within this framework are not securities. Restricting trading in stablecoins in the way securities are restricted, requiring registration with the SEC and the disclosures appropriate for instruments like stocks, or putting trading rules intended for assets with volatile prices in place around stablecoins would be a little bit like saying dollar bills themselves are securities. Stablecoins

need to work like money, to make a very simple statement, and belong in the hands of the banking regulators.

- There should be both a state and federal pathway for stablecoins. This is just the beginning of the field; there will be a lot of experimentation. It does not make sense for the OCC or the Federal Reserve to be spending significant amounts of time on a \$2mm market cap stablecoin run out of Alabama, but nor does it make sense for Alabama to be the sole overseer for a \$500b market cap stablecoin. Therefore, I would suggest that we take advantage of the relative strengths of the American system and allow each state to regulate stablecoins below a \$100b threshold that conform with these rules, but that any stablecoin that expands above this threshold must transition to federal regulation. For all state regulated stablecoins, I would suggest also allowing one of the federal regulators to be provided with all the same data and access to information as the state regulators, so that even if they are not the prudential regulator at the time, they have visibility into efforts nationwide.

Adrienne A. Harris, Superintendent, New York State Department of Financial Services:

- The New York State Department of Financial Services (DFS) regulates the virtual currency industry in New York through a comprehensive set of tools, including licensing, supervision, examination, and enforcement. DFS has two licensing and chartering regimes for entities engaging primarily in virtual currency activities, namely, the BitLicense and the limited purpose trust company (LPTC) charter. The BitLicense regulation enables companies to engage in various virtual currency activities with the approval of DFS. On the other hand, LPTCs are held to the same virtual currency-specific standards as BitLicensees but have additional powers and supervisory expectations under the Banking Law.
- The DFS has comprehensive assessment standards for financial crimes, cybersecurity, capitalization, financial/accounting, character and fitness of controlling parties, operational risk, consumer disclosures, and more. Additionally, DFS creates a detailed supervisory agreement tailored to the specific risks presented by the company's business model, and these entities are subject to ongoing supervision and examination for compliance with virtual currency regulations and supervisory agreements. Furthermore, DFS regularly issues guidance to regulated entities to make transparent more specific regulatory expectations and guardrails. If through supervision, a regulated entity is found to be non-compliant with rules, the supervisory team can quickly refer cases to DFS's enforcement division to investigate and take appropriate enforcement actions.
- Virtual currency entities are also subject to custody and capital requirements designed to mitigate industry-specific risks necessary for sound, prudential regulation. DFS has underpinned these regulatory requirements with additional guidance in January 2023 reiterating expectations for sound custody and disclosure practices, and the paramount importance of the equitable and beneficial interest in the asset always remaining with the customer. Entities must have policies, processes, and procedures in place to appropriately segregate customer funds and provide appropriate disclosures.

- The DFS oversees the issuance of stablecoins and tailors its oversight to the nuances of specific products and services using additional regulations, guidance, and supervisory agreements. The DFS has not approved the issuance of any algorithmic stablecoins due to their different characteristics in terms of design, backing, and issuance. The collapse of the algorithmic stablecoin Terra had a ripple effect across the cryptocurrency ecosystem, but the DFS's strict coin listing requirements mitigated its impact on New Yorkers. Currently, the DFS regulates five fiat-backed stablecoins and one gold-backed stablecoin, and in June 2022, it provided guidance related to the issuance of U.S. Dollar-backed stablecoins.
- The guidance includes three key elements: strict reserve requirements, confidence in redeemability, and transparency.
- Firstly, any stablecoin approved by the Department must be one-to-one backed at all times by cash or cash equivalents held in custody with U.S. state- or federally chartered depository institutions with deposits insured by the Federal Deposit Insurance Corporation (FDIC). Alternatively, asset custodians approved in advance by DFS may be used. This ensures that the stablecoin has sufficient backing to maintain its value and protect users' investments.
- Secondly, entities must adopt clear, conspicuous policies that allow for "timely" redemption not more than two full business days after the issuer receives a redemption request (i.e., "T+2" conversion in response to redemption requests). This ensures that users can redeem their stablecoins in a timely manner and have confidence in the redeemability of the stablecoin.
- Lastly, issuers are required to undergo monthly audits by an independent certified public accountant (CPA) and provide public bi-monthly attestations on the underlying reserves to provide the marketplace with the transparency needed to have confidence in their assets. This ensures that the issuer is maintaining sufficient reserves and that users can have transparency into the issuer's operations.
- In addition to the DFS Stablecoin Guidance and individual supervisory agreements, the Department is augmenting regular reporting requirements to assess an entity's capital and liquidity. Stablecoin issuers are also required to report bi-weekly their bank partnership relationships, asset reserve mix, and flows related to minting and burning. These requirements provide further transparency into the issuer's operations and ensure that the issuer is maintaining sufficient capital and liquidity.
- Strong regulation has drawn virtual currency companies to do business in New York. Crypto startups based in New York City have consistently raised more capital than companies in any other region of the country, including Silicon Valley and Miami. In 2021, nearly half of that capital was raised by New York-based companies. The Department continues to receive applications from a variety of companies which understand the critical need for a robust regulatory framework that is designed to ensure their safety and soundness and the protection of their customers.
- There is a need for a comprehensive and thoughtful state and federal framework that mirrors the mature and well-functioning regulatory system for more traditional financial institutions. As members of the Committee

contemplate federal legislation for stablecoins, Superintendent Harris suggested building on the well-established dual banking regulatory system, where state and federal regulators share supervisory and regulatory authority. This approach takes advantage of the comparative strengths of federal and state regulators and allows for comprehensive macroprudential considerations and foundational consumer and market protections, as well as nimble responses to industry developments and support for responsible innovation.

- Overall, the DFS Stablecoin Guidance and additional reporting requirements provide a level of transparency for existing and would-be issuers for how to responsibly build their business in a regulated environment. The DFS's regulatory framework is operating as intended, and customers need to know that their assets are protected. Superintendent Harris concluded by stating that continued collaboration is necessary to build a comprehensive and thoughtful state and federal framework for virtual currencies.

Virtual Currency Guidance (New York State):

- The business model of the entity will be reviewed by the NYFDS at the time of its license or charter application and will take into account a variety of potential risks including cybersecurity, technology, consumer protection, BSA/AML and sanctions compliance, safety and soundness of the issuing entity, and stability/integrity of the payment system, and any issuance of new products, including stablecoins thereafter is subject to further review and approval by the regulatory agency.
- Redeemability: The stablecoin must be fully backed by a Reserve of assets and the Issuer must have clear redemption policies approved by DFS that allow for the timely redemption of the stablecoin at a 1:1 exchange rate for the U.S. dollar, subject to reasonable conditions. In exceptional circumstances, DFS may allow redemption that does not meet the timely redemption requirement.
- Reserve: The Reserve for the stablecoin must be segregated from the issuing entity's assets and held in custody with FDIC-insured depository institutions or DFS-approved custodians. The Reserve assets must consist only of U.S. Treasury bills, fully collateralized reverse repurchase agreements, government money-market funds, and deposit accounts at depository institutions. Issuers must manage the liquidity risk of the Reserve in accordance with redemption requirements.
- Attestation: The stablecoin issuer must have the Reserve audited at least once a month by a US licensed CPA who follows the attestation standards of the AICPA. The CPA must attest to the end-of-day market value of the Reserve, the quantity of outstanding stablecoin units, whether the Reserve adequately backs the outstanding stablecoins, and whether DFS-imposed conditions on the Reserve assets have been met. Additionally, the issuer must obtain an annual attestation report by an independent CPA who attests to the effectiveness of internal controls, structure, and procedures for compliance with the requirements. The CPA reports must be made available to the public and provided to DFS within specific time frames.

MiCA Regulation (EU):

- MiCA allows the European Banking Authority (EBA) to designate significant ARTs (sARTs) and EMTs (sEMTs) based on criteria such as market capitalization, the number of holders, and interconnectedness with the financial system. Issuers of significant stablecoins will be subject to more stringent rules, including capital requirements, and will generally be supervised by the EBA instead of national authorities. This system is similar to the classification of banks as systemically important to address financial stability concerns of regulators.
- EMTs may only be offered or listed by authorized credit institutions or e-money institutions with prior notification to their supervisory authority and publication of the required white paper. An EMT will automatically be subject to MiCA rules when it references a union currency. MiCA regulates the rights and obligations of EMT issuers, including capital requirements and rules on the safeguarding of received funds, with exceptions from the e-money regime and additional rules for the investment of received funds.
- Issuers of ARTs must be established in the EU to receive authorization and must submit the required white paper for prior approval to the competent authority before publishing it. ARTs are more similar to the approval process under the Prospectus Regulation than other crypto-assets, and issuers of ART are subject to a detailed catalog of duties and rules stipulated in MiCA, including transparency and extensive governance rules, as well as capital requirements. ART issuers must maintain a reserve of assets, and the reserve needs to match the full value of the total outstanding holders' claims to ensure that issuers won't face liquidity risks when faced with a large number of simultaneous redemption requests.
- MiCA effectively limits the daily average number of transactions and trading volume associated with the use of EMTs and ARTs as means of exchange to 1 million and EUR 200 million, respectively. This limitation only applies where the token is denominated in a currency that is not an official currency of an EU member state. While some experts have expressed concern that these rules may stifle popular USD-pegged stablecoins, such as Tether's USDT, Circle's USD Coin, and Binance USD, MiCA clarifies that not all kinds of transactions will be considered associated with uses as a means of exchange.

○ **Annex 3 – Analysis of Several Major CBDC Projects**

Israel

Project timeline: *the e-Shekel is in development.*

Design choices & principles:

- The central bank conducted a pilot program in 2021 and public consultations.
- Based on previous and current research and pilot programs, a CBDC will be based on **interoperability, security, scalability, transparency, and speed of settlement.**
- Project Sela aims to analyze the cyber threats of a two-tier rCBDC that allows intermediaries to offer CBDC without financial exposure (the currency does not reside on
- the balance sheet of the intermediaries); findings will be published in mid-2023.

- Project Icebreaker evaluated a “hub-and-spoke solution to interlink different rCBDC DLT-based systems.”⁸⁸ The model reduced counterparty and settlement risk, diminished costs, and settled cross-border transactions in a few seconds while “promoting scalability, interoperability and simplicity.”⁸⁹

Regulations: None.

People's Republic of China

Project timeline: e-CNY (launched in April 2020), **pilot with 261 million wallets in use**, active in twenty-eight big cities; **cross-border project:** m-CBDC Bridge (with central banks of Thailand, the United Arab Emirates, and Hong Kong); **technology:** hybrid-DLT.

Design choices & principles:

- e-CNY operates as a **legal tender that does not bear interest**; users can hold the currency in e-wallets or in hardware wallets (reusable prepaid cards); e-CNY network has two tiers: (1) the lower tier encompassing commercial banks that exchange e-CNY with bank deposits or cash, and (2) the higher tier represented by the People’s Bank of China (PBOC); the latter manages both the supply of e-CNY and payments among commercial banks.
- designed based on the “**one coin, two databases, three centers**” concept:
 - (a) *one coin* implies that the unit of currency is e-CNY;
 - (b) the *two databases* represent the ledger of the center bank that tracks outstanding e-CNY and all records / ledgers kept by the lower tier entities;
 - (c) *three centers* refer to the identification, registration, and big data analysis centers;⁹⁰ The identification center is a database that links digital wallets with real identities, while the registration center records transactions and tracks e-CNY ownership. In addition, the analysis center oversees payment flows in order to detect illegal activities.
- **Rate of transactions per second (TPS)** in March 2022: 10,000 TPS with potential to increase to 300,000 which is a higher speed than Visa (1,700 TPS) but slower (and less scalable) than AliPay with a peak of 540,000 TPS.⁹¹ Project Hamilton (Boston Fed and MIT) presumably can function at speeds between 170,000 and 1.7 million TPS.
- The average balance of e-CNY wallets was, in April 2022, RMB 3 (less than \$0.50).⁹²

Regulations: China’s capital controls regulations and other specific legal frameworks.

South Korea

⁸⁸ BIS Innovation Hub. (March 2023). *Project Icebreaker. Breaking new paths in cross-border retail CBDC payments.* <https://www.bis.org/publ/othp61.htm>, p. 11.

⁸⁹ *Ibidem*, pp. 6-7.

⁹⁰ Greene, R. (July 2021). *Op. cit.*

⁹¹ Kumar, A. (March 2022). *A Report Card on China’s Central Bank Digital Currency: the e-CNY.* <https://www.atlanticcouncil.org/blogs/econographics/a-report-card-on-chinas-central-bank-digital-currency-the-e-cny>.

⁹² *Idem*.

Project timeline: in April 2020, the Bank of Korea (BoK) launched a twenty-two-month pilot program for a rCBDC; **technology:** Ethereum; **technology partnerships:** Samsung, Ground X.⁹³

Design choices & principles:

- BoK does not consider the implementation of a CBDC an urgency due to the high national bank account ownership and the advanced fast payment system operating in the country;⁹⁴
- **BoK conducted multiple proof-of-concept (PoC) experiments** in the August 2021 - June 2022 timeframe with the **purpose of testing the reliability of a CBDC based on DLT technology**. These experiments assessed the CBDC lifecycle management and its “P2P, offline, and cross-border payments” capabilities in a simulated virtual environment;⁹⁵
- the tested model was a hybrid CBDC design encompassing a two-tier structure in which the higher tier is represented by the central bank (i.e., BoK implements and manages the fundamental infrastructure), while the lower tier includes PSPs capable of offering end user services;
- **Results of PoC experiments:** the permissioned DLT platform was able to smoothly process end user P2P CBDC transfers; operations pertaining to the higher tier (creation-issuance-circulation-redemption-discard cycles) demonstrated “stable performance”; under normal business parameters (up to 2,000 TPS), CBDC functions including “conventional P2P payments, offline payments, digital asset transactions, and cross-border payments” performed as expected;
- **Key findings:** the system’s latency increased (the payments were settled slower) as the number of TPS, DLT nodes, and end user accounts grew; similarly, when zero knowledge proof was applied, the time of processing a single transaction increased with 14 seconds;
- BoK is running additional PoC experiments that include banks’ test platforms in order to test the CBDC in a more realistic environment.⁹⁶

Regulations: None.

The European Union (Euro Area)

Project timeline: *the Digital Euro is under review.*

April to June 2022 - A consultation with major stakeholders took place.

15 February 2023 - The first digital euro Rulebook Development Group meet took place.⁹⁷

Q2 2023 - The European Commission intends to propose a regulation to establish a digital euro.

⁹³ Atlantic Council. (2023). *Source cit.*

⁹⁴ BIS. (April 2022). *The Bank of Korea’s CBDC research: current status and key considerations.* https://www.bis.org/publ/bppdf/bispap123_m.pdf. pp. 108-109.

⁹⁵ Bank of Korea. (November 2021). *Central Bank Digital Currencies – 1st Proof of Concept Experiments.* https://www.bok.or.kr/portal/cmmn/file/fileDown.do?atchFileId=FILE_00000000036021&fileSn=1. pp. 1-2.

⁹⁶ *Ibidem.* pp. 3-6.

⁹⁷ European Central Bank – Eurosystem. (March 2023). *ECB hosts first digital euro Rulebook Development Group meeting.* https://www.ecb.europa.eu/paym/intro/news/html/ecb.mipnews230303_1.en.html

Autumn 2023 - Eurosystem decision-making bodies are expected to confirm a high-level design of a digital euro and an implementation plan. The Governing Council decision will launch a realization phase if agreement is reached.⁹⁸

Design choices & principles:

- **cooperation** between the public and private sectors is important;
- the digital euro would **represent a liability** on the balance sheet of the Eurosystem; the Eurosystem would perform “**the settlement activities** on behalf of the supervised intermediaries that distribute” the currency to end users;⁹⁹
- SIs would **take care of all user-related operations** and transaction management tasks;
- the Eurosystem would have a **minimal involvement** in the processing of user data;
- offline peer-to-peer validation is not excluded;
- the focus will be on **integration, efficiency, security, and environmental impact**;¹⁰⁰
- payment with the digital euro must be an option; a digital euro payment instrument should be **useable across the Eurozone**;
- SIs would be required to abide by **common rules, standards, and procedures**.

Regulations: None, but Directive (EU) 2015/2366 and MiCA either reference or can be adapted in order to regulate an account-based retail CBDC.¹⁰¹

United States of America (U.S.)

Project timeline: *a Digital Dollar is under review.*

Projects and research: technical assessment requested in Executive Order (EO) 14067; Digital Dollar Project (Accenture, the Digital Dollar Foundation), Project Hamilton (Federal Reserve Bank of Boston, MIT’s Digital Currency

Initiative); the FedNowSM Service (development started in August 2019) will be launched in July 2023.¹⁰²

Design choices & principles:

U.S. Government:

⁹⁸ European Central Bank – Eurosystem. (December 2022). *Progress on the investigation phase of a digital euro – second report*. https://www.ecb.europa.eu/paym/digital_euro/investigation/governance/shared/files/ecb.degov22122_1_Progress.en.pdf, pp. 3-4.

⁹⁹ *Idem*.

¹⁰⁰ *Ibidem*, pp. 6-7.

¹⁰¹ Schwarcz, S. (2021). Regulating Digital Currencies: Towards an Analytical Framework. *SSRN Electronic Journal*, pp. 17-18.

¹⁰² Federal Reserve. (March 2023). *Federal Reserve announces July launch for the FedNow Service*. <https://www.federalreserve.gov/newsevents/pressreleases/other20230315a.htm>.

- Based on official analyses and remarks of high-ranking policymakers,¹⁰³ a U.S. CBDC would be legal tender, “convertible one-for-one into reserve balances or paper currency”, and “would clear and settle with finality nearly instantly.”¹⁰⁴
- An inter-agency CBDC Working Group led by the Treasury Department is currently assessing the implications of a U.S. CBDC.¹⁰⁵
- The Federal Reserve is engaged in significant experimentation on CBDC systems.
- the Federal Reserve will launch the FedNow Service in mid-2023; this is an efficient and secure instant payment infrastructure (similar to the private system Real-Time Payments) that allows instant payments at 24x7x365 availability;
- Digital Dollar Project: the project generated “the first private sector-initiated simulated U.S. CBDC pilot”; “U.S. government should provide leadership in international digital currency standards” even if its decision is to not launch a CBDC;¹⁰⁶
- Project Hamilton: designed a core transaction processor necessary for a large retail payment system; not only did the design exceed speed and throughput requirements, but it also successfully completed 99% of transactions.¹⁰⁷

Regulations: Section 10671 of the CHIPS and Science Act of 2022; Executive Order (EO) 14067 (mandates the technical evaluation of a CBDC’s feasibility); Technical Evaluation for a U.S. Central Bank Digital Currency System (Executive Office of the U.S. President, 2022).

○ **Annex 4 – Retail CBDCs vs Wholesale CBDCs**

Retail CBDC is designed for the general public and can be used as a digital version of physical cash. Namely, this digital asset can be used for everyday transactions, such as buying goods and services or transferring money to friends and family. Retail CBDCs can offer benefits such as instant and low-cost transactions, financial inclusion for unbanked populations, and the ability to make transactions without the need for intermediaries. However, retail CBDCs may also raise concerns about privacy, security, and the potential for increased surveillance by the central bank.

With retail CBDC, the most important difference from central bank reserves is related to access features, not technology features. Unlike central bank reserves, a retail CBDC would be accessible to the general public. A retail CBDC could contribute to a more competitive and innovative payment system, support financial inclusion, and help

¹⁰³ U.S. Department of the Treasury. (March 2023). *Remarks by Under Secretary for Domestic Finance Nellie Liang During Workshop on “Next Steps to the Future of Money and Payments”*. <https://home.treasury.gov/news/press-releases/jy1314>.

¹⁰⁴ U.S. Department of the Treasury. (September 2022). *The Future of Money and Payments*. <https://home.treasury.gov/system/files/136/Future-of-Money-and-Payments.pdf>, p. 19.

¹⁰⁵ *Ibidem*, p. 46.

¹⁰⁶ The Digital Dollar Project. (May 2020). *Exploring a US CBDC*. http://digitaldollarproject.org/wp-content/uploads/2021/05/Digital-Dollar-Project-Whitepaper_vF_7_13_20.pdf.

¹⁰⁷ Federal Reserve of Bank of Boston. (February 2022). *Project Hamilton Phase 1 Executive Summary*. <https://www.bostonfed.org/publications/one-time-pubs/project-hamilton-phase-1-executive-summary.aspx#20cfd8d-c994-477e-bb57-7e49f291b155>.

preserve the singleness of the currency. However, there are also risks associated with a retail CBDC, including the potential for runs that could destabilize private sector lending during stress periods.

Wholesale CBDC is designed for financial institutions such as banks, payment processors, and other financial intermediaries. The purpose of wholesale CBDC is to facilitate interbank transactions and settlement in a more efficient and secure manner than the current systems. Wholesale CBDCs can improve the speed, transparency, and cost-effectiveness of the financial system by reducing the need for intermediaries and providing instant settlement of transactions. However, wholesale CBDCs may also raise concerns about privacy and data security since they allow central banks to monitor transactions in real-time.

Figure 1 – Example of monetary system with a direct Retail CBDC (rCBDC).
 Source: Deloitte. *Are Central Bank Digital Currencies (CBDCs) the money of tomorrow?*, p. 9.

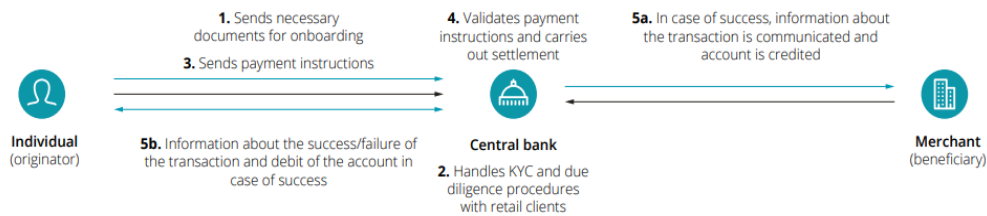
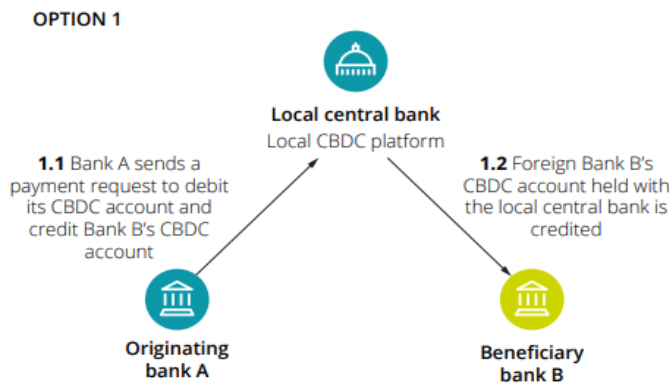


Figure 2 – Example of the monetary system with a local wholesale CBDC (wCBDC).
 Source: Deloitte. *Are Central Bank Digital Currencies (CBDCs) the money of tomorrow?*, p. 13.



For wholesale CBDC, the main difference from central bank reserves would relate to technology, while the access-related features may or may not differ. A wholesale CBDC could support interbank settlement, provide a risk-free settlement asset for tokenized securities transactions, or be used as a backing asset for stablecoins, among other benefits.

○ **Annex 5 – Motivations to Adopt a CBDC**

Motivations to implement a CBDC vary from one jurisdiction to another. Nevertheless, an analysis of the reasons for which more than 80% of central banks seriously consider launching a digital currency¹⁰⁸ provides insight on the main challenges and trade-offs states face nowadays.

One of the most cited benefits of CBDCs is their potential to democratize financial access.¹⁰⁹ In theory, a well-designed digital currency backed by a central bank facilitates cheap, easy, and safe access to money.¹¹⁰ As a result, policymakers argue in favor of CBDCs as a method of reducing the number of “unbanked” and “underbanked” individuals. Nevertheless, according to a CSR Report, a central bank must provide other financial services (e.g., permission to make retail payments, conversion of CBDC in cash, access to loans) to CBDCs account holders in order to foster financial inclusion.¹¹¹ Furthermore, the potential decline in the use of physical cash – a phenomenon pernicious to financial inclusion but caused by the introduction of a CBDC – must be balanced out with proper design choices (e.g., offline payments).

By introducing a novel payment method which offers access to safe central bank money to a wider part of the population, the entire financial system would become more stable (lower probability for the expansion of unstable payment methods or currencies), while the domestic payments sector would benefit from enhanced competition. In addition, depending on the CBDC’s characteristics, the transparency level will increase nurturing efficient detection and mitigation of illegal activities.¹¹² Privacy will be enhanced through standards and norms designed specifically with the purpose of acquiring trust, legitimacy, and wide adoption by the public.

CBDCs are regarded as instruments capable of increasing efficiency in payments. Due to the fact that payments through CBDCs are “real-time, gross, and final”, there is lower settlement risk in the system and interbank settlement and reconciliation mechanisms are no longer required.¹¹³ In the context of multi-currency CBDCs milieus, the latter fact leads to the implementation of a Payment versus Payment (PvP) system for cross-currency operations or to the creation of a Delivery versus Payment (DvP) system in the case of domestic transactions in which “the other asset could be a physical or financial asset.”¹¹⁴

As CBDCs increase the efficiency of settlements and post-market activities, they generate lower operational costs (even without taking into consideration the ESG cost related to printing money, the cost of cash can vary from 0.5% of GDP in Sweden to 1.7% of GDP in India). Additionally, a central bank digital currency can prove useful in

¹⁰⁸ PricewaterhouseCoopers. (April 2022). *PwC Global CBDC Index and Stablecoin Overview 2022*. <https://www.pwc.com/gx/en/new-ventures/cryptocurrency-assets/pwc-global-cbdc-index-stablecoin-overview-2022.pdf>. p. 5.

¹⁰⁹ Deloitte. (2022). *Central Bank Digital Currencies: Building Block of the Future of Value Transfer*. <https://www2.deloitte.com/content/dam/Deloitte/in/Documents/financial-services/in-fs-cbdc-noexp.pdf>. pp. 9-10.

¹¹⁰ International Monetary Fund (IMF). (February 2022). *Behind the Scenes of Central Bank Digital Currency Emerging Trends, Insights, and Policy Lessons*. <https://www.imf.org/-/media/Files/Publications/FTN063/2022/English/FTNEA2022004.ashx>. p. 4.

¹¹¹ Congressional Research Service. (February 2022). *Central Bank Digital Currencies: Policy Issues*. <https://sgp.fas.org/crs/misc/R46850.pdf>. pp. 20-21.

¹¹² International Monetary Fund (IMF). (February 2022). *Behind the Scenes of Central Bank Digital Currency Emerging Trends, Insights, and Policy Lessons*. p. 6.

¹¹³ Deloitte. (2022). *Central Bank Digital Currencies: Building Block of the Future of Value Transfer*. p. 9.

¹¹⁴ *Idem*.

improving tax collection, delivering social benefits, solving the issue of “high remittance costs”, and forging a resilient payments landscape.¹¹⁵

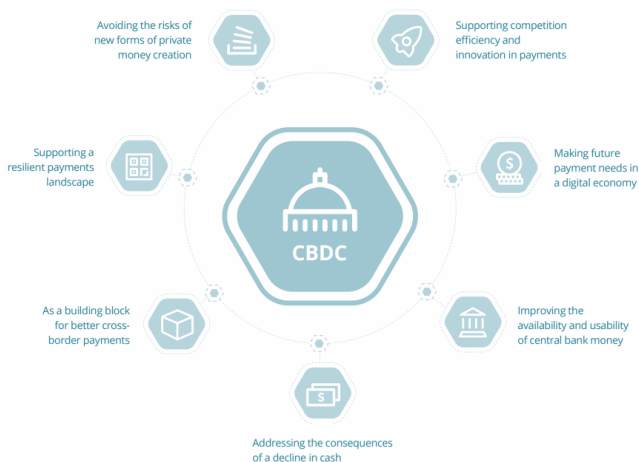


Figure 3 – Support of CBDCs in promoting monetary and financial policies.

Source: Deloitte. *Central Bank Digital Currencies: Building Block of the Future of Value Transfer*, p. 11.

o **Annex 6 – Energy Implications of CBDC**

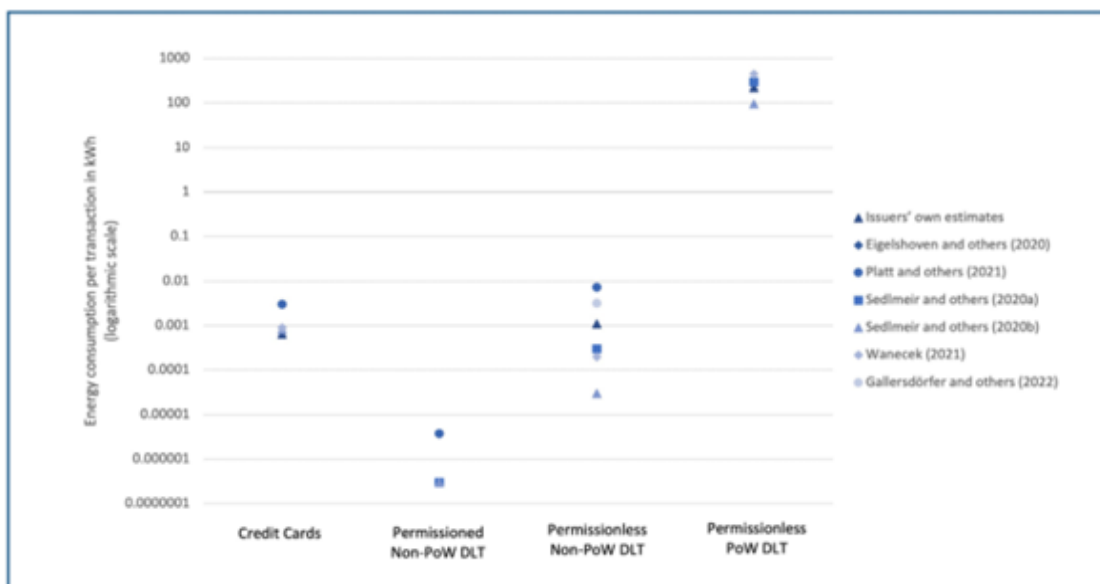


Figure 4 – Estimates of Energy Use (in kWh) per Transaction for the Core Processing of Different Payment Systems. Source: International Monetary Fund, p. 9

Notes: For the cases in which a source provides multiple estimates, the figure displays the midpoint.

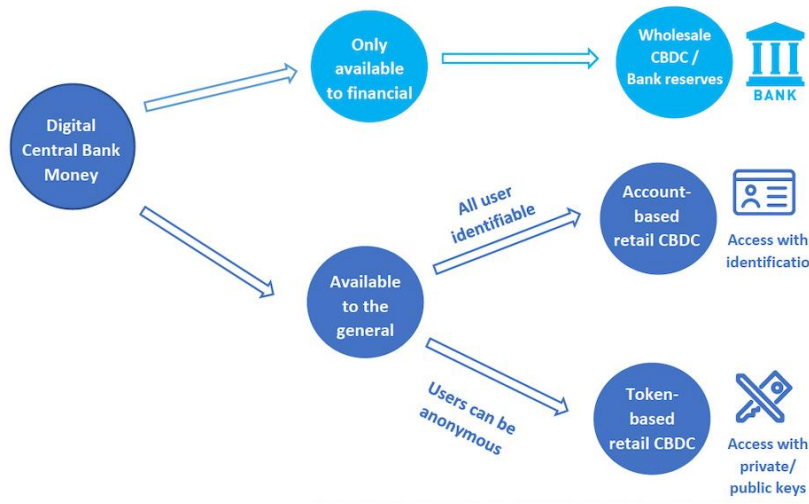
¹¹⁵ *Ibidem*. pp. 9-10.

○ **Annex 7 – CBDC Developing Stages**

| | Country | Initiation | Project | Provider | Tech. | Consensus |
|---|-------------------------|------------------------|-----------------------------|--|---------------|--|
| Legend: *Not a complete list of countries Dev. = Development Phase / € = Euro / P1 = Phase 1 | | | | | | |
| Launched | Retail CBDCs | | | | | |
| | Bahamas | 2019 | Sand Dollar | NZIA (including IBM & Zynesis) | DLT | N/A |
| | Nigeria | 2021 | e-Naira | Bitt Inc. | DLT | N/A |
| Pilot | Wholesale CBDCs* | | | | | |
| | Singapore | 2016 | Ubin | R3 Corda; Hyperledger Fabric; Quorum | DLT | Centralized; zero-knowledge proof |
| | Canada | 2016 | Jasper | P1: Ethereum; P2: R3 Corda | DLT | P2: Centralized notary node |
| | Retail CBDCs* | | | | | |
| | Uruguay | 2017 | e-Peso | Roberto Giori Company; IBM | Non-DLT | - |
| | China | 2020 | e-CNY | Feitian Technologies | Hybrid-DLT | - |
| | ECCU | 2021 | DCash | Bitt Inc.; Hyperledger Fabric | DLT | N/A |
| | South Korea | 2021 | South Korea CBDC | Ground X (Klaytn); ConsenSys Quorum | DLT | N/A |
| Jamaica | 2021 | Jamaica CBDC | eCurrency Mint Limited; DSC | Non-DLT | - | |
| Experiment | Wholesale CBDCs* | | | | | |
| | Japan + Euro Area | 2017 | Stella phase 1 | Hyperledger Fabric | DLT | Practical Byzantine Fault Tolerance (PBFT) |
| | Japan + Euro Area | 2018 | Stella phase 2 | R3 Corda; Elements; Hyperledger Fabric | DLT | Notary node |
| | Japan + Euro Area | 2019 | Stella phase 3 | Hyperledger Fabric | DLT & non-DLT | N/A |
| | Retail CBDCs* | | | | | |
| | Euro Area | 2020 | Digital € experiment (WS1) | TARGET Instant Payment Settlement (TIPS) | Non-DLT | N/A |
| | Euro Area | 2020 | Digital € experiment (WS2) | TIPS + DLT | Hybrid-DLT | N/A |
| | Euro Area | 2020 | Digital € experiment (WS3) | N/A | DLT | N/A |
| Development | Israel | 2017 (a pilot in 2021) | Sela, Icebreaker (projects) | Undecided tech provider but focus on rCBDC. Name: e-shekel | ETH | N/A |
| | U.S.A. | 2019 (debates) | Digital Dollar | Undecided (probably both rCBDC and wCBDC) | N/A | N/A |

Sources: International Monetary Fund (IMF). (June 2022). *Digital Currencies and Energy Consumptions* <https://www.imf.org/en/Publications/fintech-notes/Issues/2022/06/07/Digital-Currencies-and-Energy-Consumption-517866>. pp. 28-31. and Atlantic Council. (2023). *Central Bank Digital Currency Tracker*. <https://www.atlanticcouncil.org/cbdc-tracker/>

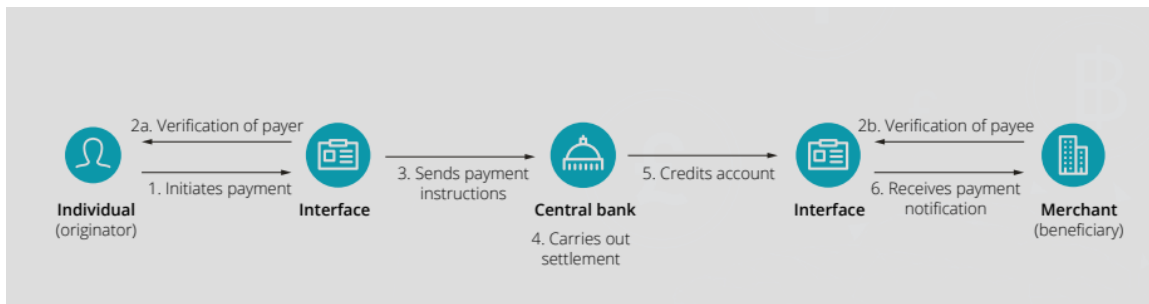
○ **Annex 8a – Forms of CBDCs**



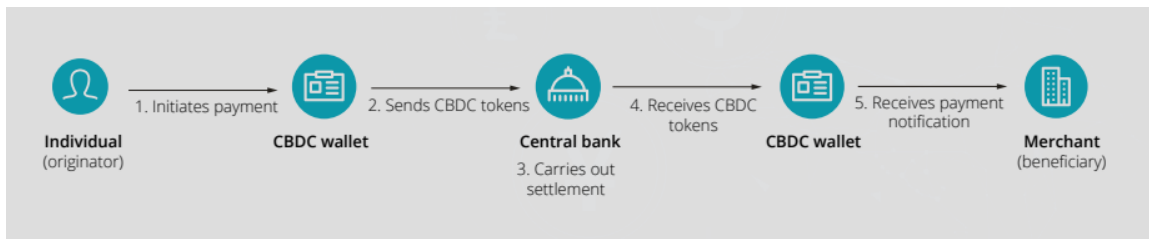
Source: BIS Innovation Hub. (June 2021). *BIS Annual Economic Report 2021*. <https://www.bis.org/publ/arpdf/ar2021e3.htm>, p. 7

○ **Annex 8b – Types of retail CBDC**

Account-based CBDCs



Token-based CBDCs



Source: Deloitte. (2020). *Are Central Bank Digital Currencies (CBDCs) the money of tomorrow?* <https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/financial-services/Banking/lu-are-central-bank-digital-currencies.pdf>, p. 6.

○ **Annex 9 – The Art World’s Blockchain Adoption**

NFT Space

NFTs, or non-fungible tokens, are unique digital assets that are stored on a blockchain. They can represent anything from digital art to collectible sports cards and virtual real estate. NFTs have become increasingly popular in recent years, with sales reaching over \$2 billion in the first quarter of 2021 alone.

The NFT market took off in 2021. Trading volume reached \$11.7 billion in the fourth quarter, increasing tenfold over the course of the year, and there were 2.7 million unique active NFT wallets (a proxy for users) by the end of 2021. The average price of an NFT rose from around \$150 to \$4,000 as interest in NFTs exploded.

This year, NFT prices have plummeted by over 50% in just one month given the market capitulation.

Despite this, the interest in NFTs has persisted. In January 2022, 2.4 million NFTs sold on OpenSea, the largest NFT marketplace, over a million more than sold in December. NFT sales by value broke records in January, with over \$4.8 billion sold on OpenSea.

Key Findings

1. The value of NFTs exchanged in 2021 was \$24.9 billion, according to DappRadar, which tracks over 30 blockchains. That’s up from \$95 million in 2020.
2. Unique active wallets -- a proxy for users -- reached 2.7 million in 2021, and 49% of those users were connected to NFT games.
3. OpenSea is the largest NFT marketplace in terms of sales value. Axie Infinity is the largest marketplace by user count.
4. A record-breaking 2.4 million NFTs (worth \$4.8 billion) were exchanged on OpenSea in January 2021, despite the average NFT price fluctuating between \$6,900 and \$1,300 that month.
5. The top five most expensive NFTs were sold in 2021. The most expensive, "The Merge" by Pak, sold for \$91.8 million, making it among the most expensive art projects auctioned.
6. NFT trading volume reached \$25 billion in 2021.

Major art auction houses like Christie’s and Sotheby’s have leaned into auctioning NFTs, and are using these decentralized assets, like the NFTs and ETH, to add value and create value across the board to not only increase profits but streamline time-intensive operations, and grow their client base. NFTs are playing a pivotal role in the development of the metaverse, allowing individuals to own virtual assets such as art, clothing, homes, and offices.

These big value sales along with retail participation have both legitimized the value of digital assets, and also created a lot of profit for Sotheby’s and Christie’s (>\$200M in just 1 year, off of digital assets).

As this technology is still relatively new and constantly evolving, there is not yet a playbook for entering the NFT space. Nor should there be. Every company should have their own unique approach to participating in this market aligning with the uniqueness of their corporate strategy.

The NFT Space

Leaders in the NFT space are developing sustainable strategies that can help deliver benefits today and create long-term growth into the web3 world.

According to a report published by PwC, successful NFT projects can do at least one of these to build a sustainable NFT strategy:

- 1. Drive Revenue:** Leverage NFTs to monetize existing intellectual property or new art / collectibles designed specifically for the medium.
- 2. Deepen Customer Engagement:** Give customers a new way to engage with your brand, as owners and / or creative collaborators (e.g. rewarding customers who contribute brand-positive content).
- 3. Improve Business Processes:** Deliver new value or utility to customers by issuing NFTs with special access rights, discounts, status or other rewards.

Some have criticized the concept of NFTs as a speculative bubble, while others see it as a new way for creators to monetize their work and for collectors to invest in unique digital assets. The value of an NFT strategy comes from building a foundation for the future, not from the temporary hype it creates.

Leading Actors in NFTs

1. Platforms / Marketplaces

OpenSea is the largest NFT marketplace by volume. Several marketplaces have emerged to simplify the process of shopping for NFTs. Creators and owners can list their NFTs for sale on these platforms, and interested buyers can make bids on the listings. The leading marketplace in terms of overall transaction value is OpenSea, which has facilitated over \$14.68 billion worth of NFT sales, as per DappRadar's data.

Axie Infinity, a video game that features NFT creatures called "Axies," has the highest number of traders, with 1.6 million using the Axie Infinity marketplace since its launch in 2018. The Axie Infinity marketplace has witnessed nearly \$4 billion worth of NFT transactions.

The CryptoPunks marketplace is home to the CryptoPunks NFT collection, which comprises some of the most expensive NFTs ever sold. The marketplace boasts the highest average NFT price among leading NFT marketplaces and has recorded over \$2 billion worth of NFT sales.

Pace Verso: An is a platform that engages artists with technology. In 2022, Pace Verso announced a partnership with Art Blocks, the industry-leading platform for generative art, to release boundary-pushing generative NFT projects by Pace's artists as well as crypto-native artists selected by and developed in partnership with Pace Verso.

Pak, a pseudonymous artist (or artist collective), has been in the forefront of digital art and crypto media for more than 20 years, best known for creating Archillect, an AI built to discover and share stimulating visual media. Digital artist Pak's newest creation, The Merge, has fetched US\$91.8 million on Nifty Gateway, with 28,983 collectors snapping up 312,686 total units of mass, or otherwise known as a nonfungible token (NFT). The price was a record for an artwork sold publicly by a living artist, according to Nifty Gateway, a leading NFT marketplace. However, the

claim is debatable, depending on whether The Merge is ultimately considered to be a single piece or a series of artworks.

2. Leading Actors in the Art World

Sotheby's and Christie's: Sotheby's and Christie's are 200+ year-old institutions, the oldest and most prominent auction houses in the world, and together, they lead the global sale of art and luxury goods. Digital assets and NFTs are a much newer creation that started gaining traction in the late 2010's. Sotheby's and Christie's strategic adoption of these assets began slowly but has grown to incorporate many elements from NFT digital art sales, accepting cryptocurrency for luxury goods, and now the Sotheby's Metaverse and Christie's x OpenSea collaboration. In the future, they are looking to build on these existing ventures, along with exploring the possibilities of tokenization to streamline authenticity and provenance tracking and fractionalizing ownership of high-value pieces.

This modernization was motivated by a drive to increase their client base, drive revenue, and streamline business processes. In 2021 alone, their push to modernize created a substantial bounce back from the pandemic and boosted sales up from 38% from the previous year. It has also attracted a new clientele of tech-savvy collectors into the art and luxury goods space. Additionally, their deep dive into the digital asset world with the Sotheby's Metaverse, serves as a platform for virtual digital art exhibitions that can be accessed globally, thereby increasing their outreach and creating another platform for customer engagement.

Rebalance Earth Eco-Tokens

Rebalance Earth is on a mission to combat climate change and preserve biodiversity, by preserving elephant lives and slowly expanding to other “Keystone Species” - small numbers of animals in a species that can create a huge impact in maintaining biodiversity and the ecosystem along with Carbon capture. The project is aimed at Elephant Sequestration. An IMF report¹¹⁶ stated that a living elephant is worth 1.75M, and a dead elephant for ivory is worth 40,000. However, poaching and killing of elephants is still very rampant. Biologists estimate that if the population of African forest elephants returned to its former size and they recovered their former range, it would increase carbon capture by 13 metric tons (1 metric ton = 1,000 kg) per hectare (10,000 square meters). A cost-benefit approach can also be used to protect, invest in, and ultimately put our ecosystems on a sustainable path. If we can reliably identify and measure the market-value services provided by natural resources—such as recreation, tourism, and carbon sequestration—we can then compare the present monetary value of these benefits with the cost of investing in them, just as we do for other assets. Households and capital markets can buy eco tokens which will be used for micro-investments for communities in that ecosystem. A local elephant can help pay for a family or maintain a community.

Below are a few steps that help explain the process of using eco-tokens:

1. Living Ecosystem - Living elephants produce an eco-credit.
2. Eco Tokens help in tracking - in a transparent, traceable, and trusted manner on an enterprise blockchain.

¹¹⁶[https://www.imf.org/en/Publications/fandd/issues/2020/09/how-african-elephants-fight-climate-change-ralph-chami#:~:text=Biologists%20estimate%20that%20if%20the,hectare%20\(10%2C000%20square%20meters\)](https://www.imf.org/en/Publications/fandd/issues/2020/09/how-african-elephants-fight-climate-change-ralph-chami#:~:text=Biologists%20estimate%20that%20if%20the,hectare%20(10%2C000%20square%20meters))

3. Data can be collected for each token based on the living conditions and needs of the species and can be made available for free to scientists.
4. An independent governance body will be needed to oversee the process.

• Taxonomy

Bitcoin: Bitcoin was the first blockchain created and the largest blockchain network. It was launched in 2009 by Satoshi Nakamoto. Bitcoin uses proof-of-work to validate transactions and create new blocks on the blockchain, thereby the blockchain is more decentralized than Proof-of-Stake. Its native cryptocurrency is Bitcoin (BTC).

Blockchain: A blockchain is a decentralized and distributed digital ledger that is used to record transactions or data in a secure and transparent manner. It is composed of a series of blocks, where each block contains a set of transactions and a unique cryptographic hash that links it to the previous block in the chain. This creates an immutable and tamper-evident record of all the transactions that have occurred on the network. Provides a network for businesses and individuals to share workflow, data, and value in a connected digital world.

A private blockchain is a permissioned network. places restrictions on who can join the network. It allows members to set various types of rights, similar to a traditional permissioned application. Example: consortia of banks allowing merchants to join.

Members share sensitive information, PII or financial, and operate under heavy legal /compliance regulations. Therefore, members are known in advance. Member secure network. Have rules which can add / remove members. Example: banks, customs, shipping provider.

A Public Blockchain is a permissionless blockchain, which means anyone can join and participate in the network. All data that is stored on-chain can be seen by everyone, as can all transactions. When you hear BITCOIN or ETH, you are hearing about public blockchains.

Public blockchains harness voluntary resources of the community to bootstrap and grow the network so node runners are generally not known in advance nor identified.

As a permissionless network, openness is a public blockchain's biggest benefit. As long as you have a connection to the internet, you can participate, make an impact on the blockchain and access all the applications and economic opportunities presented by that blockchain.

Central Bank Digital Currency (CBDC): virtual money backed, issued, and regulated by a central bank;¹¹⁷ it represents the “digital form of a country’s sovereign currency”.¹¹⁸

Crypto Assets: Crypto Assets are a type of private sector digital asset that depend on cryptography and DLT, or similar technology. While other assets may involve digital representations of value, assets are only crypto-assets if they rely on cryptography and DLT, such as blockchain.

Cryptocurrency: Cryptocurrency is a type of digital currency that uses cryptography to secure and verify transactions.

¹¹⁷ Atlantic Council. (2023). CBDC Tracker.

¹¹⁸ International Monetary Fund (IMF). (June 2022). *Digital Currencies and Energy Consumptions*. p. 3.

Consensus Mechanisms: Consensus mechanisms provide mechanisms for all users to agree on the ledger entries and transactions. Different consensus mechanisms enforce different rules for when participants can submit ledger updates. The most common are PoW and PoS .

Decentralized Exchange (DEX): The service that is a peer-to-peer marketplace where crypto holders can trade cryptocurrencies.

Decentralized Finance (DeFi): DeFi is a collective term for financial products and services such as lending, borrowing and investing that is designed to be open, transparent and accessible without the need for centralized authorities.

Democratic backsliding: devaluation of democratic institutions and/or principles.

Distributed Ledger Technology (DLT): protocols and supporting digital infrastructure through which computers from different geographical locations initiate, record, and validate transactions across a network of nodes.

DLT Nodes: instances of software which are part of a DLT network. They can participate in the consensus mechanism and store either a part or the entire ledger.

Ethereum: Ethereum was launched in 2015 and was one of the first blockchains that introduced the concept of smart contracts which support an ecosystem of DeFi and NFT applications, making it possible to focus more on developing advanced applications. Ethereum smart contracts enable the launching of projects such as Aave and Compound by creating a token standard and applications such as Uniswap and NFTs.

Hashrate: A hashrate is the total computational power used each second to mine and process PoW blockchains.

Layer-1: foundational layer of the blockchain infrastructure. This structure is responsible for running the consensus protocol, processing transactions and maintaining the distributed ledger (ex. Bitcoin, Ethereum, Solana and Cardano).

Layer-2: a scaling solution for Layer-1 blockchains that improve scalability and efficiency in Layer-1 (ex. Polygon, Mantle, Arbitrum and Optimism). These blockchains play a key role in enabling the operation of DeFi and cryptocurrencies transactions.

Markets in Crypto-Assets (MiCA): the EU's law that is intended to close gaps in existing EU financial services legislation by establishing a harmonized set of rules for crypto-assets. MiCA categorized three crypto-assets that are subject to different requirements:

- (1) electronic money tokens or e-money tokens (EMTs): crypto-asset that purport to maintain a stable value by referencing to the value of one official currency; electronic coins and banknotes used for payment purposes (ex. stablecoin)
- (2) asset-referenced tokens (ARTs): tokens to maintain a stable value by referencing to any other value or right or a combination of thereof, including one or more official currencies
- (3) all other crypto-assets: not EMTs or ARTs and utility tokens (ex. BTC, ETH)

EU Parliament passed on October 5, 2022, and the final vote on the EU will be in April 2023.

Lending: The service that crypto holders can lend cryptocurrency without intermediaries which allows the crypto holders to earn interest.

Miners: Miners are participants who submit blocks to the network to compute transactions. Miners are incentivized to add blocks to the consensus ledger by performing energy-intensive computations, because they receive compensation in the form of newly minted crypto-assets for adding a block to the blockchain, and they collect fees

associated with transactions within the block. As a crypto-asset becomes more valuable, the mining rewards also become more valuable. This attracts more miners and computing resources to solve the cryptographic math problem.

Node: A node on a blockchain is a computer or device that participates in the network by maintaining a copy of the blockchain and verifying transactions. Each node communicates with other nodes on the network to maintain a consistent and up-to-date version of the blockchain ledger.

Payment-versus-payment (PvP): a settlement mechanism that allows the final transfer of a payment in one currency to occur only if the final transfer of a payment in another currency or currencies takes place.

Proof of Stake (PoS): PoS mechanism is the most popular alternative to the energy-intensive PoW consensus mechanism. This is used for networks such as Ethereum 2.0, Solana, Cardano, and others. In PoS, participants — called validators — typically “stake” an amount of crypto-assets for the opportunity to be chosen to add a new block of transactions to the ledger. Dozens of variations exist within the PoS consensus mechanism; variations generally share the principle that trust is inferred by a participant’s willingness to risk their valuable crypto-assets. Because PoS validators rely on risking assets rather than computing power to validate transactions, the electricity use of PoS crypto-assets is much lower than PoW crypto-assets (over 99.5% lower usage).

Proof of Work (PoW): PoW consensus mechanisms, which are currently primarily used for Bitcoin, and some other blockchains, require the completion of a computationally-intensive process before a set of transactions, or “block,” is validated and added to the ledger. This ensures that participants are willing to spend significant computational and energy resources in order to add blocks to the ledger. This approach makes it more difficult for malicious participants to force an inaccurate ledger, because they would need to amass a large amount of computing resources and expend a significant amount of energy to achieve a consensus. This PoW “economic model” means that a PoW network will generally use more electricity as the crypto-asset’s value (and network) grows, so long as the distribution of the crypto-asset among miners stays constant.

Retail Central Bank Digital Currency (rCBDC): a digital payment instrument considered a direct liability of the central bank and available to the public. It is denominated in the national unit of account.¹¹⁹

Real-time gross settlement (RTGS) systems: “a gross settlement system in which both processing and final settlement of funds transfer instructions” take place in real time.¹²⁰

Stake / Staking: Staking refers to the process of holding (or “locking up”) a certain amount of cryptocurrency in a wallet or smart contract for a specific period of time in order to participate in the network’s consensus mechanism and earn rewards. Staking is commonly used in proof-of-stake (PoS) consensus mechanisms, where validators (also called “stakers”) are chosen to create new blocks and validate transactions based on the amount of cryptocurrency they hold and “stake” (lock up) in the network. Validators are incentivized to act honestly and securely by earning rewards for their participation in the network. Staking can provide a way for cryptocurrency holders to earn passive income on their holdings while also contributing to the security and stability of the network. However, staking also carries some risks, such as the possibility of slashing (losing a portion of the staked funds) if the validator behaves maliciously or the network experiences a vulnerability.

Supervised intermediaries (SIs): entities (e.g., credit institutions or PSPs) that operate between a central bank and end users. They are overseen by a public authority.

¹¹⁹ BIS Innovation Hub. (March 2023). *Project Icebreaker. Breaking new paths in cross-border retail CBDC payments*. p. 9.

¹²⁰ BIS. (March 1997). *Real-time gross settlement systems*.

Wholesale Central Bank Digital Currency (wCBDC): a digital payment instrument for the “settlement of interbank transfers and related wholesale transactions”. It fulfills the same purposes as central bank reserves but offers additional functionality.¹²¹

Web3.0: the next generation of world wide web using blockchain technology and artificial intelligence.

Web1: The internet of information, Read Only. 1990 - 2005

Web2: The internet of interactions, Read and Write. 2005 - 2020.

Web3: The internet of value, Read-Write-Own. 2020 - present

*Other relevant definitions are encompassed in the Digital euro glossary.*¹²²

¹²¹ BIS Innovation Hub. (June 2021). *BIS Annual Economic Report 2021*. pp. 71-72.

¹²² European Central Bank – Eurosystem. (March 2023). *Digital euro glossary*.

• Bibliography

Atlantic Council. (March 2023). Central Bank Digital Currency Tracker. <https://www.atlanticcouncil.org/cbdctracker/>.

Avalanche, (2023), Avalanche Platform, <https://docs.avax.network/overview/getting-started/avalanche-platform#platform-chain-p-chain>.

Banca Sella. Filippo Chiricozzi.

Bank of Canada. (June 2017). Financial System Review. *Project Jasper: Are Distributed Wholesale Payment Systems Feasible Yet?*. <https://www.bankofcanada.ca/wp-content/uploads/2017/05/fsr-june-2017-chapman.pdf>.

Bank of Korea. (November 2021). *Central Bank Digital Currencies – 1st Proof of Concept Experiments*. https://www.bok.or.kr/portal/cmmn/file/fileDown.do?atchFileId=FILE_000000000036021&fileSn=1.

BIS. (2022). *E-CNY: main objectives, guiding principles and inclusion considerations*. https://www.bis.org/publ/bppdf/bispap123_e.pdf.

BIS. (April 2022). *The Bank of Korea's CBDC research: current status and key considerations*. https://www.bis.org/publ/bppdf/bispap123_m.pdf.

BIS. (June 2022). *BIS Annual Economic Report 2022 - The future monetary system*. <https://www.bis.org/publ/arpdf/ar2022e3.pdf>.

BIS. (March 1997). *Real-time gross settlement systems*. <https://www.bis.org/cpmi/publ/d22.htm>.

BIS. (September 2021). *Central bank digital currencies: user needs and adoption*. https://www.bis.org/publ/othp42_user_needs.pdf.

BIS Innovation Hub. (June 2021). *BIS Annual Economic Report 2021*. <https://www.bis.org/publ/arpdf/ar2021e3.htm>.

BIS Innovation Hub. (March 2023). *Project Icebreaker. Breaking new paths in cross-border retail CBDC payments*. <https://www.bis.org/publ/othp61.htm>.

BIS Innovation Hub. (2022). *Project Sela to test a cyber-secure retail CBDC architecture that reduces the financial exposure of intermediaries*. <https://www.bis.org/about/bisih/topics/cbdc/sela.htm>.

Cambridge Bitcoin Electricity Consumption Index. (April 2023). *Bitcoin mining Map*, https://ccaf.io/cbeci/mining_map.

Christie's x OpenSea; Christie's and Chainalysis;

Cointelegraph. (October 2022). <https://cointelegraph.com/news/the-merge-brings-down-ethereum-s-network-power-consumption-by-over-99-9>

Congressional Research Service. (February 2022). *Central Bank Digital Currencies: Policy Issues*. <https://sgp.fas.org/crs/misc/R46850.pdf>.

Council of the European Union. (October 2022) *Proposal for a Regulation of the European Parliament and of the Council on Markets in Crypto-assets, and amending Directive (EU) 2019/1937 (MiCA)*. <https://data.consilium.europa.eu/doc/document/ST-13198-2022-INIT/en/pdf>.

Crypto Climate. (March 2023). <https://cryptoclimate.org/accord/>

CSIS. (April 2022). *China's Progress Towards a Central Bank Digital Currency*. <https://www.csis.org/blogs/new-perspectives-asia/chinas-progress-towards-central-bank-digital-currency>.

Davidson, S. (August 2022). *Digital Dynasties: How China's Cryptocurrency Could Unseat the Dollar*. Harvard International Review. <https://hir.harvard.edu/digital-dynasties-how-chinas-cryptocurrency-could-unseat-the-dollar/>.

DappRadar, NFT trading volume increased from \$95M to \$25B from 2020 to 2021, which tracks over 30 blockchains.

Deloitte. (2020). *Are Central Bank Digital Currencies (CBDCs) the money of tomorrow?* <https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/financial-services/Banking/lu-are-central-bank-digital-currencies.pdf>.

Deloitte. (2022). *Central Bank Digital Currencies: Building Block of the Future of Value Transfer*. <https://www2.deloitte.com/content/dam/Deloitte/in/Documents/financial-services/in-fs-cbdc-noexp.pdf>.

DeFiLlama. (April 2023). *Total Value Locked All Chains*. <https://defillama.com/chains>.

Digiconomist. (March 2023). *Bitcoin energy consumption index*. <https://digiconomist.net/bitcoin-energy-consumption>.

Digital Planet - The Fletcher School's Institute for Business in the Global Context. (October 2021). *How Green is the Greenback? An Analysis of the Environmental Costs of Cash in the United States*. <https://sites.tufts.edu/digitalplanet/how-green-is-the-greenback-an-analysis-of-the-environmental-costs-of-cash-in-the-united-states>.

EUR-Lex. (December 2015). *Directive (EU) 2015/2366 of the European Parliament and of the Council on payment services in the internal market*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015L2366&qid=1610641825076>.

EUR-Lex. (October 2022). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions: Digitalising the energy system - EU action plan*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0552&qid=1666369684560>.

European Central Bank – Eurosystem. (December 2022). *Progress on the investigation phase of a digital euro – second report*. https://www.ecb.europa.eu/paym/digital_euro/investigation/governance/shared/files/ecb.degov221221_Progress.en.pdf.

European Central Bank – Eurosystem. (March 2023). *Digital euro glossary*. https://www.ecb.europa.eu/paym/digital_euro/investigation/profuse/shared/files/dedocs/ecb.dedocs220420.en.pdf?b268d673898445396fb1a59efbcf01f3.

European Central Bank – Eurosystem. (March 2023). *ECB hosts first digital euro Rulebook Development Group meeting*. https://www.ecb.europa.eu/paym/intro/news/html/ecb.mip_news230303_1.en.html.

European Commission. (March 2023). *A digital euro for the EU*. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13392-A-digital-euro-for-the-EU_en.

Eunike Ventures; Amy Henry, CEO and Co-Founder, a company that uses blockchain to improve energy efficiency.

Federal Reserve (April 18, 2023). *Considerations for a Central Bank Digital Currency*. <https://www.federalreserve.gov/newsevents/speech/bowman20230418a.htm>.

Federal Reserve. (January 2023). *Money and Payments: The U.S. Dollar in the Age of Digital Transformation*. <https://www.federalreserve.gov/publications/files/money-and-payments-20220120.pdf>.

Federal Reserve. (March 2023). *Federal Reserve announces July launch for the FedNow Service*. <https://www.federalreserve.gov/newsevents/pressreleases/other20230315a.htm>.

Federal Reserve. (March 2023). *The FedNowSM Service Readiness Guide*. <https://www.frbservices.org/binaries/content/assets/crsocms/financial-services/fednow/prepare-for-fednow/fednow-service-readiness-guide.pdf>

Federal Reserve of Bank of Boston. (February 2022). *Project Hamilton Phase 1 Executive Summary*. <https://www.bostonfed.org/publications/one-time-pubs/project-hamilton-phase-1-executive-summary.aspx#20cfc8d-c994-477e-bb57-7e49f291b155>.

G7 Countries. (October 2021). *G7 Public Policy Principles for Retail Central Bank Digital Currencies*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1025235/G7_Public_Policy_Principles_for_Retail_CBDC_FINAL.pdf.

Global Carbon Reward. (September 2019). *First Annual Global Climate Restoration Forum*. The United Nations Headquarters. <https://globalcarbonreward.org/wp-content/uploads/2021/05/GCR-UN-Forum-AtoZ-Climate-Finance-V8a.pdf>.

GPO. (March 2023). *118th Congress: S661*. <https://www.congress.gov/118/bills/s661/BILLS-118s661is.pdf>.

GPO. (December 2022), *117th Congress: S5210*. <https://www.congress.gov/117/bills/s5210/BILLS-117s5210is.pdf>.

Greene, R. (July 2021). *What Will Be the Impact of China's State-Sponsored Digital Currency?* Carnegie Endowment for International Peace. <https://carnegieendowment.org/2021/07/01/what-will-be-impact-of-china-s-state-sponsored-digital-currency-pub-84868>.

Harvard Business Review. (May 2021). *How Much Energy Does Bitcoin Actually Consume?* <https://hbr.org/2021/05/how-much-energy-does-bitcoin-actually-consume>

Horowitz, A. (2022). *State of Crypto*. a16zcrypto. https://api.a16zcrypto.com/wp-content/uploads/2022/05/state-of-crypto-2022_a16z-crypto.pdf. Pp.18.

Huffman.(March 2023). *Democrats Introduce Bill, set Hearing on Crypto Energy Use*. <https://huffman.house.gov/media-center/in-the-news/democrats-introduce-bill-set-hearing-on-crypto-energy-use#:~:text=The%20%22Crypto%2DAsset%20Environmental%20Transparency,investigate%20the%20industry's%20environmental%20impacts>

IEA. (July 2019). *Bitcoin energy use: mined the gap*. <https://www.iea.org/commentaries/bitcoin-energy-use-mined-the-gap>

IEA. (October 2022). *Bitcoin price, hashrate and difficulties indexes, 2017-2019*. <https://www.iea.org/data-and-statistics/charts/bitcoin-price-hashrate-and-difficulties-indexes-2017-2019>

International Environmental Agency (IEA). (July 2019). *Bitcoin energy use: mined the gap*. <https://www.iea.org/commentaries/bitcoin-energy-use-mined-the-gap>.

International Environmental Agency (IEA). (October 2022). *Bitcoin price, hashrate and difficulties indexes, 2017-2019*. <https://www.iea.org/data-and-statistics/charts/bitcoin-price-hashrate-and-difficulties-indexes-2017-2019>

International Environmental Agency (IEA). (2022). *Norway 2022: Executive summary*, <https://www.iea.org/reports/norway-2022/executive-summary>.

International Monetary Fund (IMF). (February 2022). *Behind the Scenes of Central Bank Digital Currency Emerging Trends, Insights, and Policy Lessons*. <https://www.imf.org/-/media/Files/Publications/FTN063/2022/English/FTNEA2022004.ashx>.

International Monetary Fund (IMF). (June 2022). *Digital Currencies and Energy Consumptions*. <https://www.imf.org/en/Publications/fintech-notes/Issues/2022/06/07/Digital-Currencies-and-Energy-Consumption-517866>.

International Monetary Fund (IMF). (June 2022). *Fintech notes: Digital currencies and energy consumptions*. <https://www.imf.org/en/Publications/fintech-notes/Issues/2022/06/07/Digital-Currencies-and-Energy-Consumption-517866>. pp.9-10.

International Monetary Fund (IMF). (November 2020). *Legal Aspects of Central Bank Digital Currency: Central Bank and Monetary Law Considerations*. <https://www.imf.org/-/media/Files/Publications/WP/2020/English/wpia2020254-print-pdf.ashx>.

IMF December 2020 report: How African Elephants Fight Climate Change: Biologists estimate- if population of African forest elephants returned to its former size and recovered their former range, carbon capture will increase by 13 metric tons (1 mt = 1,000 kg) per hectare (10,000 sq meters).

Jiang, J. and Lucero, K. (January 11, 2021). Background and Implications of China's Central Bank Digital Currency: E-CNY. SSRN Electrical Journal. <http://dx.doi.org/10.2139/ssrn.3774479>.

Kumar, A. (March 2022). *A Report Card on China's Central Bank Digital Currency: the e-CNY*. Atlantic Council. <https://www.atlanticcouncil.org/blogs/econographics/a-report-card-on-chinas-central-bank-digital-currency-the-e-cny>.

KPMG. (2022). *The digital euro and its impact on banking*. <https://kpmg.com/nl/en/home/insights/2022/12/the-digital-euro-and-its-impact-on-banking.html>.

Lee, S., & Park, J. (2022). *Environmental Implications of a Central Bank Digital Currency*. World Bank Group. <https://documents1.worldbank.org/curated/en/099143507042228192/pdf/IDU0110707310d28b041b70bb560cc1f4b1f41d4.pdf>.

Lührmann, A. and Lindberg, S. I. (2019) A third wave of autocratization is here: what is new about it? *Democratization*. 26:7. pp. 1095-1113. DOI: 10.1080/13510347.2019.1582029.

Michael B. Greenwald. (May 2022). Harvard Kennedy School Belfer Center. *What Will Determine the Future of Money?* <https://www.belfercenter.org/publication/what-will-determine-future-money>.

Nebraska Public Power District. Senate Environment and Public Works Subcommittee hearing on Crypto-asset mining and its impact on the environment. (March 2023).

New York Times. (April 2023). The Real World Costs of the Digital Race for Bitcoin <https://www.nytimes.com/2023/04/09/business/bitcoin-mining-electricity-pollution.html>

New York Times. (April 2023). Bitcoin Uses More Electricity Than Some Counties- How is That Possible? <https://www.nytimes.com/interactive/2021/09/03/climate/bitcoin-carbon-footprint-electricity.html>

Open-Sea, the largest NFT marketplace by trade volume, most NFT transactions occur on the Ethereum blockchain, using the Ethereum cryptocurrency.

Politico. (March 2022). *The possibility of the digital euro*. <https://www.politico.eu/article/finance-banking-the-digital-euro-cryptocurrency-central-banks-currency>.

Politico.(January2023). New York Partially Banned Crypto-Mining. Now Environmentalists Want More. <https://www.politico.com/news/2023/01/07/new-york-cryptocurrency-mining-ban-00072564#:~:text=Gov.,a%20model%20for%20other%20states.>

PricewaterhouseCoopers. (April 2022). *PwC Global CBDC Index and Stablecoin Overview 2022*. <https://www.pwc.com/gx/en/new-ventures/cryptocurrency-assets/pwc-global-cbdc-index-stablecoin-overview-2022.pdf>.

PricewaterhouseCoopers. (2023). *How to build a sustainable NFT strategy*. PwC. <https://www.pwc.com/us/en/tech-effect/emerging-tech/build-sustainable-nft-strategy.html>

<https://www.rebalance.earth/mission>

U.S. Department of the Treasury. (September 2022). *The Future of Money and Payments*. <https://home.treasury.gov/system/files/136/Future-of-Money-and-Payments.pdf>.

U.S. Department of the Treasury. (March 2023). *Remarks by Under Secretary for Domestic Finance Nellie Liang During Workshop on “Next Steps to the Future of Money and Payments”*. <https://home.treasury.gov/news/press-releases/jy1314>.

Senate Environment and Public Works Committee Hearing. (March 2023). *Air, Climate, and Environment Impacts of Crypto Mining* <https://www.epw.senate.gov/public/index.cfm/2023/3/air-climate-and-environmental-impacts-of-crypto-asset-mining-legislative-hearing-on-s-the-crypto-asset-environmental-transparency-act-of-2023>

Sethaput, V., & Innet, S. (2023). Blockchain application for central bank digital currencies (CBDC). *Cluster computing*, 1–15. Advance online publication. <https://doi.org/10.1007/s10586-022-03962-z>.

Schwarz, S. (2021). Regulating Digital Currencies: Towards an Analytical Framework. *SSRN Electronic Journal*.

Stanford Law School. (April 2021). *Background and Implications of China’s Central Bank Digital Currency: E-CNY*. <https://law.stanford.edu/2021/04/06/background-and-implications-of-chinas-central-bank-digital-currency-e-cny>.

Sveriges Riksbank. (April 2021). *E-krona Pilot. Phase 1*. Sveriges Riksbank, Stockholm. <https://www.riksbank.se/en-gb/payments--cash/e-krona/e-krona-reports/e-krona-pilot-phase-1-report-3/>

Tassev, L. (2022). Kazakhstan shuts down over 100 crypto mining farms. Bitcoin.com. <https://news.bitcoin.com/kazakhstan-shuts-down-over-100-crypto-mining-farms/>

Tech Transparency Project. (March 2023). *Cryptominers Sweetheart Deal with Texas Threatens an Already Fragile Grid*. https://techtransparencyproject.cdn.prismic.io/techtransparencyproject/369c5690-7e26-427a-9116-26f46616b45d_Crypto+Texas+Report.pdf

The Atlantic. (March 2023). *Crypto is Mostly Over. Its Carbon Emissions Are Not*. https://www.theatlantic.com/science/archive/2023/03/crypto-bitcoin-mining-carbon-emissions-climate-change-impact/673468/?utm_source=newsletter&utm_medium=email&utm_campaign=weekly-planet&utm_content=20230322&utm_term=The%20Weekly%20Planet

Tassev, L. (March 2022). *Kazakhstan shuts down over 100 crypto mining farms*. Bitcoin.com. <https://news.bitcoin.com/kazakhstan-shuts-down-over-100-crypto-mining-farms/>.

The Digital Dollar Project. (January 2023). *White Paper 2.0 - Revisiting the Digital Dollar Project’s exploration of a U.S. central bank digital currency*. https://digitaldollarproject.org/wp-content/uploads/2023/01/DDP-Whitepaper-2.0_2023.pdf.

The Digital Dollar Project. (May 2020). *Exploring a US CBDC*. http://digitaldollarproject.org/wp-content/uploads/2021/05/Digital-Dollar-Project-Whitepaper_vF_7_13_20.pdf.

The Digital Dollar Project. (November 2022). *Digital Dollar Project and DTCC: Security Settlement Pilot*. <https://www.dtcc.com/-/media/Files/Downloads/WhitePapers/DDP-DTCC-Pilot-Report.pdf>.

The Treasury Department. (September 2022). *The Future of Money and Payments*. <https://home.treasury.gov/system/files/136/Future-of-Money-and-Payments.pdf>.

Velicky, M. (November 2023). *Renewable energy transition facilitated by Bitcoin*. ACS Publications. <https://pubs.acs.org/doi/10.1021/acssuschemeng.2c06077>

White House. (March 2022). *Executive order on ensuring responsible development of digital assets*, <https://www.whitehouse.gov/briefing-room/presidential-actions/2022/03/09/executive-order-on-ensuring-responsible-development-of-digital-assets/>.

White House. (September 2022). *Technical Evaluation for a U.S. Central Bank Digital Currency System*. <https://www.whitehouse.gov/wp-content/uploads/2022/09/09-2022-Technical-Evaluation-US-CBDC-System.pdf>.

White House. (September 2022). *Climate and energy Implications of Crypto-Assets in the United States Report* <https://www.whitehouse.gov/wp-content/uploads/2022/09/09-2022-Crypto-Assets-and-Climate-Report.pdf>

Yang, J., & Zhou, G. (2022). A study on the influence mechanism of CBDC on monetary policy: An analysis based on e-CNY. *PLoS one*, 17(7), e0268471. <https://doi.org/10.1371/journal.pone.0268471>.