An Overview of Blockchain for

Climate Action and Sustainability

BLOCKCHAIN FOR EUROPE

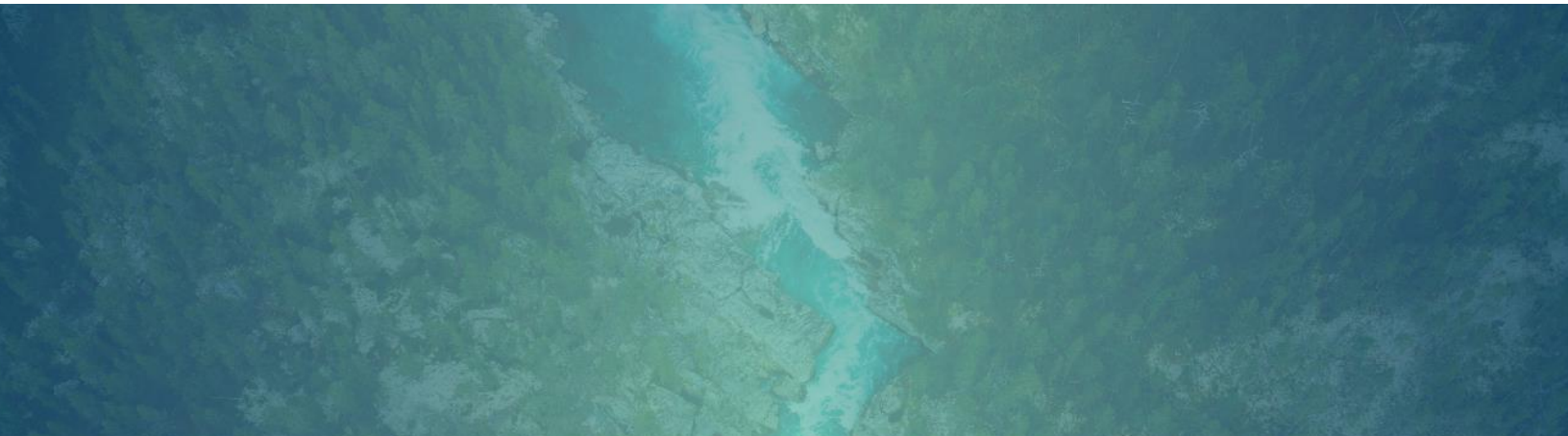
IOTA FOUNDATION

Discussions on blockchain and sustainability usually focus on the energy consumption of different consensus mechanisms, emphasizing the extensive environmental impact of specific blockchain networks and getting stuck in a self-referential – albeit important – discussion that fails to produce any positive effect and instead considers that all blockchain protocols are the same when it comes to energy consumption.

It is important to note that blockchain technology "*has the potential to both contribute to the problem of climate change and help address it*", as acknowledged by the World Economic Forum. Blockchain can be energy efficient and contribute to a net improvement in sustainability efforts. But to do so, appropriate blockchain technology with low energy consumption must be selected when designing sustainability applications. New protocol designs aim to further improve the energy consumption and efficiency of traditional blockchains. For example, these new solutions remove Proof of Work (PoW) as the main access control mechanism, and replace it with less energy intensive mechanisms, such as Proof of Stake (PoS) or Directed Acyclic Graph (DAG) architecture. Nano, Fantom, AlephZero, and IOTA are examples of protocols working with these cutting-edge technologies. It is also worth pointing out that Proof of Work is not the dominant blockchain consensus mechanism anymore, as Bitcoin and Dogecoin are the only major projects still based on PoW. Most blockchain networks out there already use control consensus mechanisms that are much more sustainable, which shows how there is a general misconception around the "negative climate impact of the whole blockchain sector". With a PoS consensus mechanism, for example, the network relies on tokens 'staked' by the nodes sustaining the network, rather than on their computational power. This can reduce the overall energy consumption of the network by up to 99%, as demonstrated by the so-called "Merge", the historic upgrade of the Ethereum network which moved it from operating on a PoW consensus to a PoS one.

However, rather than delving into the details of the energy consumption of each different consensus mechanism adopted by different projects, the aim of this paper is to discuss instead some of the concrete real-world use cases that make the most of the environmental potential of blockchain technology. The paper thus outlines what the technology can do to solve the climate and sustainability challenges and explains why we should start talking about "**blockchain FOR sustainability**", rather than only focusing on "blockchain's sustainability".

The overall objective of the experts and associations that contributed to this paper is to showcase the environmental potential of blockchain to policy and decision-makers that develop regulatory frameworks for the safe and sustainable development of blockchain technology around the world.



SUPPLY CHAINS AND CIRCULAR ECONOMY

According to the European Environmental Agency, a circular economy is a part of the green economy that more widely addresses human welfare, lifestyles, and consumption models. Since 1900, the world's population has quadrupled. Resource consumption has grown by a factor of 10 and is expected to double by 2030.

The Sustainable Grid

Environmental	Social	Governance
• Mitigation of and adaptation to climate change. • Water and marine resources. • Resource use and circular economy. • Pollution. • Biodiversity and ecosystems.	• Equal opportunities, access to the labor market, gender equality, and disability. • Working conditions, including wages, social dialogue, and work-life balance. • Human rights, fundamental freedoms, and democratic principles, with reference to the International Bill of Human Rights. • Adequate or equal presence of women in management positions (boards of directors) and during meetings (webinars, Zoominars).	• The role of administrative, management, and control bodies. • Ethics and corporate culture, including the fight against corruption. • Political commitments and lobbying activities. • Management of relations with business partners. • Internal control and risk management.

Source: A.Lanotte – Tax Notes International (US): "Green Finance: Sustainable Growth And the Circular Economy"

A circular economy is an industrial model that is intentionally regenerative. Products are designed to facilitate reuse, disassembly, restoration, and recycling. Businesses keep resources in use as long as possible to obtain their maximum value, and then recover and regenerate products and materials at the end of their service life. Eco-design is a key element of the circular economy. New engineering (or re-engineering) of production processes, goods, services, and value chains according to the eco-design criteria includes: boosting resource and energy efficiency; eliminating toxic and dangerous chemicals; reducing environmental impacts in production, consumption, and end-of-life management; increasing product reuse, regeneration, and material recycling; preventing waste production and disposal; and the tokenization of assets (for example, Carbon Credits).

To meet the EU's 2030 climate and energy targets and achieve the objectives of the European Green Deal, it is crucial to redirect investments toward sustainable projects. The COVID-19 pandemic has reinforced the need to redirect capital flows to sustainable projects to make economies, businesses, societies, and health systems more resilient in the face of climate and environmental shocks.

The role of blockchain in boosting green finance and shifting from a linear to a circular economy.

Blockchain and smart contracts have essential characteristics to cope with the industrial transition to a circular economy. Blockchain is useful in addressing data challenges (for example, the recording and traceability of production loops in multi-tiered supply chains), while smart contracts can automate important processes. Blockchain can be used to track items in traditional supply chains in real-time. In a circular economy, blockchain can be used to organize, analyse, and manage complex networks in reverse logistics – that is, the tracing of outputs that become inputs for recycling or remanufacturing processes (Wang et al., 2020). Some examples of live-projects that are already providing similar innovative solutions include Real Items, a Web3 platform for tracing products across all stages of the supply chain, with more than 11.5 million products already on-chain, as well as the Recycle-to-Earn blockchain protocol created by the Zero Waste Foundation, which aims to establish the decentralized incentive structure needed to achieve high performance recycling on a global scale. The table below summarizes areas in which blockchain functions as a key technology for circular supply chain management.

Key areas of applying blockchain	Traditional supply chains	Circular economy chains
Reducing the costs of checking financial flows	✓	✓
Increasing speed in physical interactions and communications	✓	✓
Risk control of data	✓	✓
Better resource management reducing waste	✓	✓
Identification of suppliers, trace and benchmarc supplier performance	✓	✓
Procurement: tracking of the life cycle of products	✓	✓
Audit operations	✓	✓
Material management in the logistics process	✓	✓
Reverse logistics: obtain accurate information about the time, location, quality and conditions of materials, products and waste for recycling, refurbishment, re-use, etc.		✓
Green product management: monitor products to measure greenhouse gas emission, allow customers to differentiate between green products and non-green products.		✓
Reusing waste across different circular supply chains		✓

Figure 1. Blockchain and product tokenization in a circular economy. Source: self-elaborated based on Wang et al. (2020) and Narayan & Tidström (2020).

As the circular economy gains traction, participants such as customers, producers, distributors, and retailers will be more involved in the process where parallel production loops occur, increasing the complexity as well as opportunities to aggregate value by recycling, reusing, refurbishing, remanufacturing, or repairing. Under this new paradigm, elevating the costs of acquiring information is a losing game for everyone, whereas information sharing, cooperation, and securing knowledge aim at value creation.

In order to achieve value creation, firms, distributors, retailers, consumers, and manufacturers are more than ever compelled to simultaneously compete and cooperate, coining the new term “coopetition” (Narayan & Tidström, 2020). Under “coopetition”, participants interact and iterate in every possible loop. In this case, it is necessary to create a technological ecosystem where all relevant parties can exchange information without restrictions. Blockchain is precisely a technology that enables data to be created, organized, and managed in complex networks.

In addition to blockchain, tokenization can facilitate systemic coordination in a multi-tiered circular economy. The resulting token contains metadata and interoperates with smart contracts for faster validation of resource provenance, tags, or digital passport verification. The token also allows queries for peer-to-peer cooperation in circular production loops. Also, the token can facilitate investment allocation, the implementation of green taxation, or the monitoring of environmental regulatory compliance.

A tokenized product can aggregate data in any transaction. Figure 2 shows a basic architecture where every token transaction generates information registered on a blockchain. In a second layer, blockchain applications process data, generate analytics and provide tracking and traceability services used in developing applications for the different users in the ecosystem. During the design stage, the token can incorporate data from the materials for the manufacturing process, or data from recycled or repaired components required for remanufacturing. The information permits tracking materials to be recycled or products to recuperate for redesign purposes. In the manufacturing stage, smart contracts can automate procurement processes by checking if suppliers meet the fulfilment conditions.

Also, additional qualifications in the item (for example, green digital passports, certifications, or watermarks) can be aggregated into the token's data. Customers can also use information in the token to select green products or re-use/repair products to avoid waste. The outcome is an immense cloud of information, accessible and trustworthy enough to incentivize "coopetition" schemes.

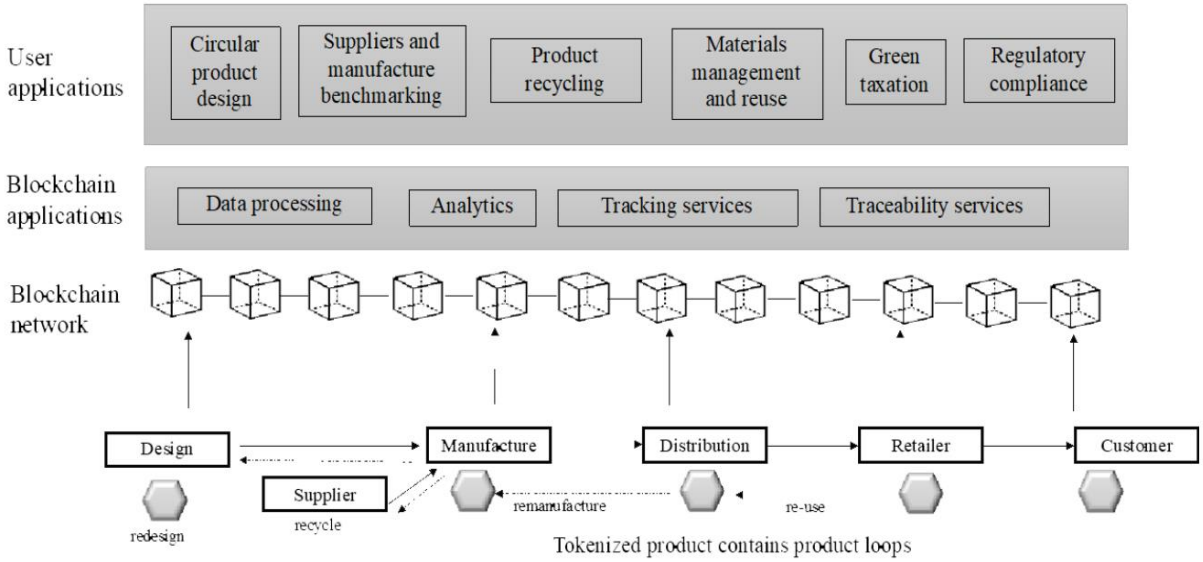


Figure 1. Blockchain and product tokenization in a circular economy. Source: self-elaborated based on Wang et al. (2020) and Narayan & Tidström (2020).

Blockchain for carbon monitoring, reporting, and verification

To achieve the 2030 Agenda, data for monitoring and evaluation must be accurately and transparently tracked and attributed to relevant stakeholders. Data and standards empower stakeholders to make greener decisions, and so new digital solutions for measurement, reporting, and verification (MRV) are especially important, particularly when it comes to measuring the efficacy of climate actions.

One next-generation digital solution for measurement, reporting, and verification is IOTA, used in climate monitoring to guarantee the veracity of the data utilized by climate researchers and institutions, relying on data that cannot be tampered with and therefore is data that can be trusted. For example, IOTA is used in the DMRV project, funded by the government of Canada.

The DMRV project answers the need for improving the interoperability of MRV systems and activities to avoid double-counting and double-claiming, as well as to support climate change strategies to be more cost-effective and efficient in achieving their goals.

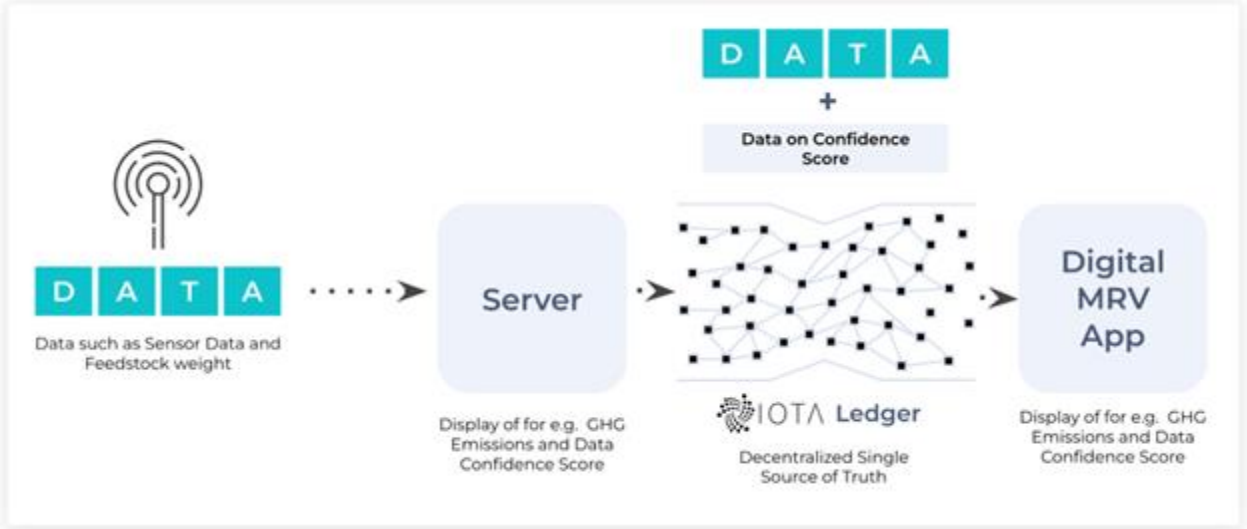


Figure 1: Example DMRV process flow

In summary, blockchain solutions enhance the transparency, accuracy, efficiency, trust, and value of climate data through digital solutions for collection, calculation, reporting, and assurance. Solutions using DLT represent a shift from manual collection and assessment of data to automated solutions providing validated data sets that generate trust and can drive more investment to the sector and avoid green-washing.

SUSTAINABLE FINANCE

The impact of asset tokenization: how disruptive technology can boost green finance.

The Blockchain Council defined tokenization as "*the process of transforming ownerships and rights of particular assets into a digital form*." Any asset can be tokenized and the rights to that asset can be represented on a DLT. Each token lives on the blockchain and carries with it the rights to the represented asset.

Innovative companies and multinational enterprises are moving items of value across blockchain networks. Tokenization converts the rights to an asset into a digital token within a blockchain, with one token representing an intangible asset or a defined portion. This process plays a considerable role in the exchange of product information. Everything is recorded on the blockchain, increasing trust and transparency between counterparts. They can also anticipate future objectives and projects by using smart contracts.

Thus, asset tokenization can also help shift financial investments towards more sustainable activities, which is a key driver for greening the financial sector. Emissions trading systems (ETS) have proven to be an effective and efficient form of carbon pricing and are an important climate policy instrument, with the ability to mitigate climate change on a large scale. Achieving the Paris Agreement climate targets will require the widespread use of carbon pricing. Putting a price on carbon emissions that considers the negative externality of climate change creates an incentive for the invisible hand of the market to move economies away from burning fossil fuels. A price on carbon to encourage this is arguably the most effective way to lower carbon emissions. Although carbon dioxide is not the only greenhouse gas, it does the most damage. For investors, carbon traded in these markets can be viewed as an attractive asset class with well-understood risk premium drivers.

Carbon credits and the potential of NFTs for a carbon credit system

In the case of carbon credits, it is essential to mention that monitoring, reporting, and verification practices in more than 90% of the cases are currently done in an analog fashion, requiring in-person audit visits. The digital solutions used until now are not much better because of a lack of appropriate security and trust, which reduces the utility of the data due to a lack of confidence in it. Investors, sellers, buyers, and other stakeholders are limited from participating in climate markets and climate finance without secure, immutable, and reliable data sources available in near real-time. An innovative project in this regard is Covalent, which is developing an all-in-one platform for carbon credit management, providing stakeholders with a safe and reliable platform to issue, purchase and trade CRD-based carbon credits that are certified by the ratings of independent researchers & organizations.

Moreover, carbon credit NFTs have multiple advantages. For example, they can prevent greenwashing and double counting, and they can also produce effective liquidity. NFTs can provide a transparent solution that keeps track of all transactions in an immutable way, giving buyers complete information and records about the carbon credit. Moreover, they eliminate the risk of double counting because of their non-fungibility. Sadly, double-counting is a constant threat in the carbon credit market, where two or more organizations claim the same emission reduction. Furthermore, carbon credits are not easy to sell as long as they are liquid assets; however, when they are minted and part of a marketplace, they are easy and quickly accessible. Furthermore, carbon credit NFTs can be staked to generate passive income for the organization that owns them. In addition, NFTs can be linked to a specific high-quality carbon offset initiative to support its financing.

Figure 2: Exemplary features of a carbon credit NFT marketplace

As previously mentioned, the blockchain protocol used in climate-related projects must be climate-friendly and energy efficient. There's no use undermining the work of these projects with energy-intensive tech, which is what many people still believe blockchain to be. This perception is primarily due to the Proof of Work consensus mechanism, from which many blockchains are moving away to a less energy-intensive model such as Proof of Stake. And that's just blockchain. A new generation of decentralized ledger technologies, such as IOTA, avoids the problem entirely by using DAG as their underlying architecture.

DEMOCRATIC PARTICIPATION IN CLIMATE CHANGE INITIATIVES

Blockchain to enhance democratic participation in climate change initiatives

A simple definition of democracy is the people's government. At its origins, democracy was exercised directly, and all powers were invested in the people and were exercised by them. This is also known as “pure democracy”. Modern democracy is a system of indirect participation in which we “freely” elect representatives and endow them with the power to make decisions on our behalf. Blockchain solutions can democratize societies and processes by bringing back the decision-making power to the people, especially considering the potential of blockchain to empower disadvantaged communities that have been historically discriminated against, enabling them to make and execute decisions on their own.

For example, there are blockchain use cases that work at the intersection of climate, agriculture, and financial empowerment. One such use case is Yenna Tech, which tokenizes traditional assets such as land to enable microfinancing tools that support local farmers to access the resources they need to work their land. Yenna Tech tokenizes and fractions land ownership and enables different stakeholders to invest in fractions of the land. The farmers use the funds to develop and cultivate the land, while the investors receive rewards at the end of the harvest. This kind of solution provides financial resources to farmers that cannot access loans in the traditional financial sector, empowering these communities with economic tools to develop their land, we enable them to participate in markets from which they were previously excluded. Therefore, blockchain use cases like Yenna Tech not only empower farmers with the resources they need to work their land and become financially sustainable but also in the long term break down poverty cycles.

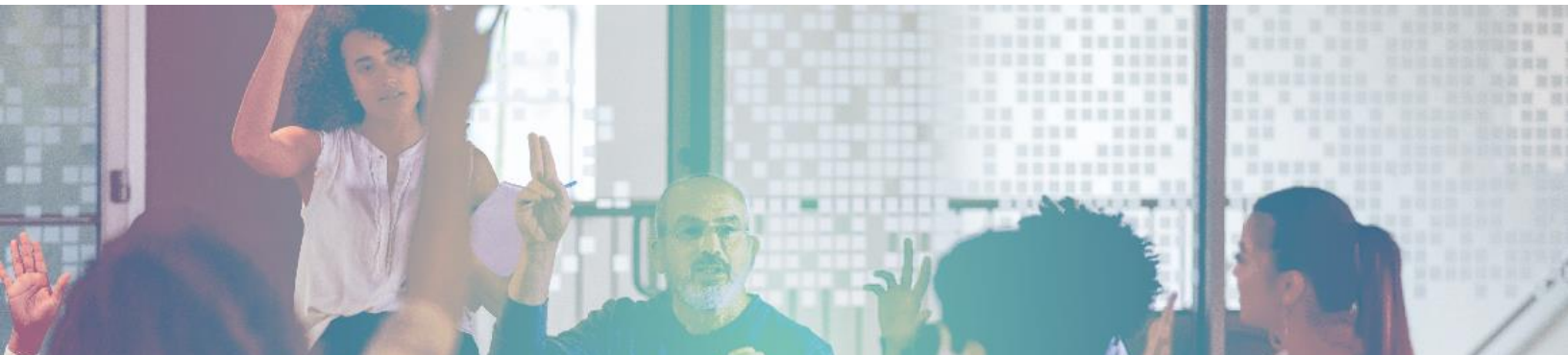
Another great example of a project using DLT to empower local communities is Dimitra, a global 'AgTech' company that deployed a blockchain-based Deforestation Certification to make it easier for smallholder farmers to provide documentation ensuring that goods brought to the local market are obtained sustainably and in compliance with impending deforestation regulations in the EU. Dimitra's mission is to deliver high-level tech for agriculture, including satellite monitoring, AI and blockchain technology, to small and medium farmers around the world. Dimitra's integrated platform then helps them record their farming activities, create and receive detailed dashboard reports, and receive recommendations that will allow them to make informed decisions that directly impact their standard of living.

Moreover, the consensus mechanisms and governance structures of blockchain can enhance democracy by enabling all members to participate. However, this will depend on the governance structure itself. Any blockchain project that intends to be democratic should follow the 12 Principles of Good Democratic Governance when setting the rules of the game.

Figure 3: Exemplary advantages of blockchain-based climate applications

Climate applications can also enable peer-to-peer energy-sharing models, making energy consumption more efficient as well as local. A great example of this is the work conducted by VIA, a technology company that is developing different blockchain-based solutions, including projects to improve and incentivise sustainable energy consumption habits. VIA's Skylight initiative, for example, enables grid flexibility by allowing utilities to target specific customers, at specific times, with incentives and real time settlement, which would help unlocking the two-way power flow associated with a "green grid". VIA's Web3 platform will then also allow verification of the fuel mix of the charge and discharge of EV batteries, incorporating VIA's zero-knowledge proof (ZKP) to maintain the privacy of sensitive data that currently creates friction for the data owner in the decision to share this information.

Blockchain-based climate applications can also enhance the supply chain so that consumers receive information about the origin, production, and transportation of goods, enabling them to make more conscious and sustainable decisions by understanding which products come with higher or lower carbon footprints. This helps empowering people to not only make conscious decisions about their consuming habits but also to organize themself and put pressure on brands to become more sustainable and environmentally responsible. Last but not least, new blockchain-based transparent donation systems allow small NGOs working on environmental causes to fund their projects, free from the agenda of large, powerful donors. Moreover, they enable individual donors to understand in a transparent and immutable way how their donations are being used, which can incentivize them to continue with their support of a particular project. And this overview doesn't include Decentralized Finance solutions and voting powers via smart contracts, which can also empower democratization.



UPCOMING POLICY AND INDUSTRY INITIATIVES

When looking at the policy pipeline, in the EU and elsewhere, there are a few relevant initiatives ahead of us that could have a clear and direct impact on the sustainability of blockchain technology, as well as on the public perception of how blockchain can help achieve sustainable objectives. The sustainability impact of crypto assets remains a core policy concern in the EU and globally. Naturally, this has implications for blockchain technology as well. As in all forms of regulatory policy, successful collaboration between policymakers and industry actors is needed to ensure that public policy objectives are achieved, the industry can align effectively, and future innovation is environmentally friendly.

For example, the EU's Markets in Crypto-Assets (MiCA) Regulation will require issuers of crypto assets to declare information on the climate and environmental impact of their projects. This is a good first step in building transparency for consumers and consistency across the sector. The specifics of these rules will be developed and overseen by the European Securities and Markets Authority (ESMA) and compliance will become a core part of the supervision of crypto asset actors in the EU. As these rules develop, and their impact is assessed, there will likely be others in the future - particularly as exposure to climate-related financial risks from crypto assets starts to be incorporated into financial services firms' prudential reporting.

Another example of the EU thinking about the environmental impact of crypto assets can be seen in the Action Plan on Digitalising the Energy System, adopted by the European Commission in October 2022. Acknowledging the increasing use of crypto assets and the consequent increase in the energy consumption used to mine these assets, the Commission highlights the need to "use only the most energy-efficient versions of the technology", arguing that the energy increase is mainly due to the "relatively outdated proof-of-work consensus mechanism". The Action Plan even goes so far as to suggest that EU Member States should be ready to implement measures to lower the electricity consumption of crypto asset miners during times of energy crisis. Beyond this first response, the Commission will develop a report by 2025 that includes a description of the environmental and climate impact of new technologies in the crypto asset market, including an assessment of policy options to mitigate these adverse impacts. Concretely, this would culminate in the development of an energy-efficiency label for blockchains, as well as minimum energy-efficiency requirements, in close cooperation with international standardization bodies.

On the level of coordination outside the EU, there is not yet much in the way of guidelines to support jurisdictions' work on developing policies for the sustainability of blockchain or crypto assets. That should change as the EU's approach (which is world-leading at this point), starts to bear fruit. But the issue is clearly on the agenda of international policy-makers: for example, the Bank for International Settlements (BIS) Innovation Hub is working on using blockchain to support trading in green bonds, while the Organisation for Economic Cooperation and Development (OECD) has called for further work on developing policy to manage the potential climate impact of crypto assets.

Moreover, the blockchain ecosystem is mobilizing itself to advocate for the power of blockchain for good. An example is the BC100+ initiative, which brings together a variety of organizations across different sectors. The initiative's main goal is to raise awareness about the potential of blockchain for social impact and sustainability and explores the potential of blockchain to address systemic issues such as inequality, poverty, and climate change by rebuilding trust, empowering communities, asserting accountabilities, and re-distributing value on the global level. At its core, BC100+ intends to promote quality debate, raise awareness and clarify the opportunities of blockchain's role in realizing the UN Charter Values and the 2030 Agenda while generating a space for dialogue between blockchain projects and web2 organizations working on the development sector, such as NGOs, non-profits and UN Agencies. Quoting BC00+: "*With its core features, blockchain technology could play a role in the acceleration of much-needed changes within our global food system, energy infrastructure, and biodiversity protection among other issues*".

CONCLUSION

This article has aimed to provide an overview of some interesting use-cases that showcase the potential of blockchain technology and how this can have a positive impact on the global fight against climate change. This is clearly not an exhaustive list of all the concrete applications that are deploying DLT to help the fight against climate change. The objective is rather to provide a starting point for shifting the focus of the current narrative surrounding blockchain technology and sustainability towards how DLT can have a positive impact on the fight to protect our planet.

In any case, it is important to remember that technology is just a tool. We have recently seen how it can be misused to scam and take advantage of people. But these actions result from human greed, ambition, and selfishness, not from the technology itself. The technology's purpose and application are our choices. There are multiple projects, foundations, and individuals devoted to improving lives and fighting the climate crisis through blockchain – and their numbers are growing. There will always be bad and good actors, but it is up to the sector's leaders – whether on the policy level, adoption, or development – to set the industry on the right path and help positive projects scale to a global level to generate the positive impact we so desperately need. Hence, this initiative also fits within the ongoing efforts of all the associations, organisations and other stakeholders that aim to support the policymaking process, as rule makers around the world are called to regulate many aspects of blockchain technology applications, including the intersection of blockchain and sustainability, as elaborated in the section above.

IOTA Foundation, Blockchain for Europe and the other blockchain companies and associations involved remain ready to support the work of international institutions that are tasked to develop regulatory frameworks for the safe and sustainable deployment of DLT across the economy.

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