CHAIN REACTIONS

THEMATIC BRIEF ENERGY – ENVIRONMENT 2

BLOCKCHAINS AND ENVIRONMENT

01.2021

ABOUT INNOVATION BRIEFS

CHAIN REACTIONS addresses the challenge for industrial regions to increase regional capacity to absorb new knowledge and turn it into competitiveness edge and business value. There is a strong need to help SMEs to overcome capacity shortages for innovation and integration into transnational value chains.

The project aims at empowering regional ecosystems with the knowledge and tools to help businesses overcome those barriers and generate sustained growth through value chain innovation. During the project lifetime CHAIN REACTIONS publish thematic briefs presenting the rationale behind specific innovation deployment within selected business areas.

Following to the previous project briefs dealing with Blockchain revolution in Supply Chain Management, in the software industry and in the bioeconomy, this new brief of the CHAIN REACTION project presents the impact of this technology on environmental issues but also its potential to contribute to the environment protection.

BLOCKCHAIN AND THE ENVIRONMENT

The environmental impact of Blockchains technologies

Blockchains consume exorbitant amount of energy because of the algorithm followed for its creation. This consumption is particularly high in the case of mining cryptocurrencies (e.g. to generate a new Bitcoin). In this case, the software have to resolve a type of puzzle to generate a reward. The solution and the transaction of the newly generated coin are then added to the blockchain. The problem with blockchains technologies is that it only works well when done at scale: an individual server is worthless.

The increasing reliance on the servers needed to power blockchain takes an environmental impact. Servers themselves indeed take up physical rooms in buildings and waste huge amounts of energy. Data centers are very reliant on energy: a single data center can eat up more power than a medium-size town. Therefore, from the beginning of the blockchain revolution in 2014, there were some concerns raised about energy consumption of blockchain solutions [1]. Since then, researchers all around the world have analysed the energy consumption caused by Bitcoin in numerous scientific publications [2]. Researchers recently determined electricity consumption for Bitcoin to be between 60 and 125 TWh per year [3]. This is in the range of the annual electricity consumption of countries such as Austria (75 GWh) and Norway (125 GWh).

Results regarding the overall energy consumption of blockchain technology in general are rare. Indeed, determining the exact value for the energy consumption of a multitude of open, distributed networks is a hard task because the precise number of participants, the properties of their hardware, and the effort which they put into mining are unknown.

The impact of data centers is anyway not only on energy use but on the local environment. Ireland that is already home to some of the biggest facilities in Europe is experiencing a surge in data processing, and by extension, a surge in buildings to house them: as of January 2020, 31 data centers had planning permission in Ireland [4].

Figure 1 - Bitcoin Energy Consumption Index [5]

Proof-of-Stake vs. Proof of Work to reduce energy consumption

The cryptography is usually framed within a "proof-of-work" (PoW) protocol, which rewards miners for solving complex equations — the reward being digital coins. This process requires a huge amount of computing power, which translates to a massive amount of energy consumption.

The original mechanism to validate transactions (consensus protocol) in a blockchain network is known as „proof-of-work". This mechanism is used for cryptography and rewards miners with digital coins' for solving complex equations. When people solve the mathematical challenges that allow them to validate blockchain transactions through proof of work, they get rewarded with more cryptocurrency. But, as mentioned before, this process requires a huge amount of computing power, which translates to a massive amount of energy consumption, because it relies on multiple computers undertaking complex calculations to reach consensus on updates to the ledger [6]. At the end, the work must be moderately hard (yet feasible) on the prover or requester side but easy to check for the verifier or service provider.

In response to this excessive use of energy, a new model, called "proof-of-stake (PoS)," has emerged. The proof-of-stake method is significantly less energy-intensive than proof-of-work validation. Unlike PoW, there are no miners involved in the consensus process. Instead, participants in the network who want to be involved in proving the validity of network transactions and creating blocks in a PoS network have to hold a certain stake in the network. In the case of cryptocurrencies, the proof of stake (PoS) will attribute mining power to the proportion of coins held by a miner. This way, instead of utilizing energy to answer PoW puzzles, a PoS miner is limited to mining a percentage of transactions that is reflective of his or her ownership stake. For instance, a miner who owns 2% of the Bitcoin available can theoretically mine only 2% of the blocks.

If building blockchain applications move toward less energy-intensive methods of verification like PoS, there should be a resultant decrease in blockchain energy consumption.

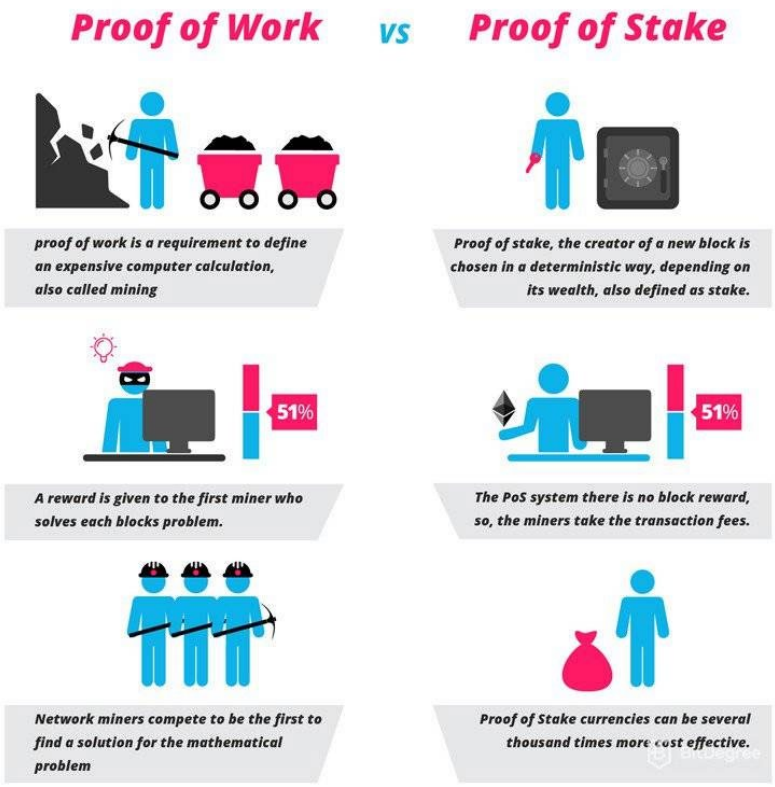


Figure 2 - Proof of Work vs Proof of Stake [7]

Red Belly Blockchain

Researchers are trying to find further blockchains approaches that work differently from the ones that use so much energy. One example is the Red Belly Blockchain developed by the technology arm of Australia's national science agency, CSIRO's Data61, and the Concurrent Systems Research Group at the University of Sydney: this solution is solving the issues that have plagued previous generations of blockchain systems including environmental impact from significant energy use which refers to how many units of information can be processed in a short amount of time. This solution is capable of performing tens of thousands of transactions per second. Thus, the Red Belly Blockchain does not consume as much electricity as traditional blockchain solutions. It offers performance that scales without an equivalent increase in electricity consumption. This in contrast to the traditional blockchain networks. The Red Belly Blockchain was recently experimented on Amazon Web Services' (AWS) global cloud infrastructure (1,000 virtual machines across 14 of AWS' 18 geographic regions) [8].

Overall Blockchain's potential to protect the environment

The management of natural resources and the protection of ecosystem requires trust and confidence in the rules governing exchange and possession. How to demonstrate that governments and other users respect entitlements to use a natural resource? How to verify that companies reduced environmental impact as expected? Trust and transparency would clearly encourage the deployment of environmentally sustainable actions. As already discussed in the last CHAIN REACTION brief, blockchain technologies are very useful to achieve transparency and trust in supply chain management. It provides a verifiable and transparent record of who exchanges what with whom – and therefore who has what at a given time. This feature can also be used in the context of environmental sustainability to improve the slow, costly intermediation associated with current models of environmental governance.

Blockchain also has the potential to empower broader communities of stakeholders but a number of conditions will have to be met. One important issue is that not all blockchains are public. "Permissioned' blockchains" – in contrast to "public blockchains" are designed to restrict access to only verified parties. This has important implications for the extent to which blockchains can disrupt existing power dynamics and reduce intermediates, such as governments or dominant firms [9].

Figure 3 - Examples of how blockchain is currently being applied to environmental sustainability challenges [10]

The blockchain is already being used to directly benefit the environment in several different ways. For instance, blockchain can also be used to track the carbon footprint of products, which can then determine the amount of carbon tax to be charged.

However, blockchain applications can also have environmental benefits without focusing on environmental sustainability challenges explicitly. For example, blockchain's impact on supply chain management will have tangible benefits for the environment as a by-product of its improvement of global supply chains organisation or while dealing with application in the bioeconomy sector (see previous REACTION brief).

Today's global supply chains are complex environments that require a huge number of products, parties, and processes and above all, total cooperation. The product of this environment is facing down a supply chain that's wildly inefficient and inflexible, and the impact of global supply chains on the environment has been devastating. A report from McKinsey shows that 90% of the damage caused to the environment created by consumer-packaged goods is the product of supply chain issues [11].

The blockchain technology offers a new option to seek out sustainable supply chain strategies that were functionally unavailable in this environment without the application of blockchain. Transparency such as real-time tracking of goods as they move and change hands throughout the supply chain will help companies and their partners to see exactly where everything in their chain is or is moving at any point and anywhere in the world. Blockchain provides a new and dynamic means of organizing tracking data and putting it to use. Everyone in the chain will be able to make better-informed decisions.

Poseidon Foundation to control carbon footprint

The Poseidon Foundation implemented an AI-based blockchain platform called Reduce. It analyzes a product to produce its carbon footprint and relates it to a credit value, which shows the true dynamic cost of consumption. Thus, the Reduce platform provides a vital new tool for retailers to shift behaviours and integrate real climate action into every retail transaction at the point-of-sale. Using blockchain technology, Poseidon empowers everyone to address the carbon impact of lifestyle choices to track and share the positive impact of transactions on individual projects with peers [12].

Rainforest Foundation to protect rainforest

Rainforest Foundation and Regen Network have launched a blockchain based pilot project in the indigenous community of Buen Jardin de Callarú, Peru. Regen Network has created a blockchain based direct payments system where local communities can interface with investors and donors. This immutable system ensures that donor payments get where they need to go, and anyone can track how much went where and when. They are using smart contracts and near real time satellite data to detect deforestation and forest cover to get funds directly to this frontline rainforest community based on verified evidence that they are protecting their forests. By drastically reducing typical upfront project costs and aligning short term economic gain with long term ecological health, they are rebuilding the economics of community-based forest protection. Payments can be issued to communities that have proven to protect or regenerate their forests [13]. They aim to expand this cost-effective system to communities across the Amazon, dramatically increasing the scale of investment to these frontline forest protectors that produce results that will have a global impact on climate.

DRIFE: Ondemand transportation

The blockchain project called DRIFE brings on-demand transportation to the blockchain. It's a decentralized system that lets people rate their drivers and see payment details for their trips entered into the blockchain as ledger transactions. Uber and Lyft helped people get comfortable with the idea of using on-demand drivers to take them to their destinations. DRIFE hopes to eliminate some transparency problems for transportation associated with using the gig economy - free market system in which temporary positions are common and organizations hire independent workers for short-term commitments [14].

Blockchain can drive the Circular Economy

The Circular Economy can only be successful through incentivising new behaviours, like sustainable resource production and consumption, product repurposing and recycling. Another key issue is assuring that the repurposed or recycled goods people and organisations buy aren’t made from virgin materials. If recycling is one of the best ways to reduce landfill waste, for companies it can look like a practice that doesn’t have much reward. Trust and transparency are therefore needed in order avoid return to current linear economy. Blockchain technology, combined with other technologies like IoT and AI, should give these businesses and consumers this needed visibility and thus help to optimize recycling systems that are already in place.

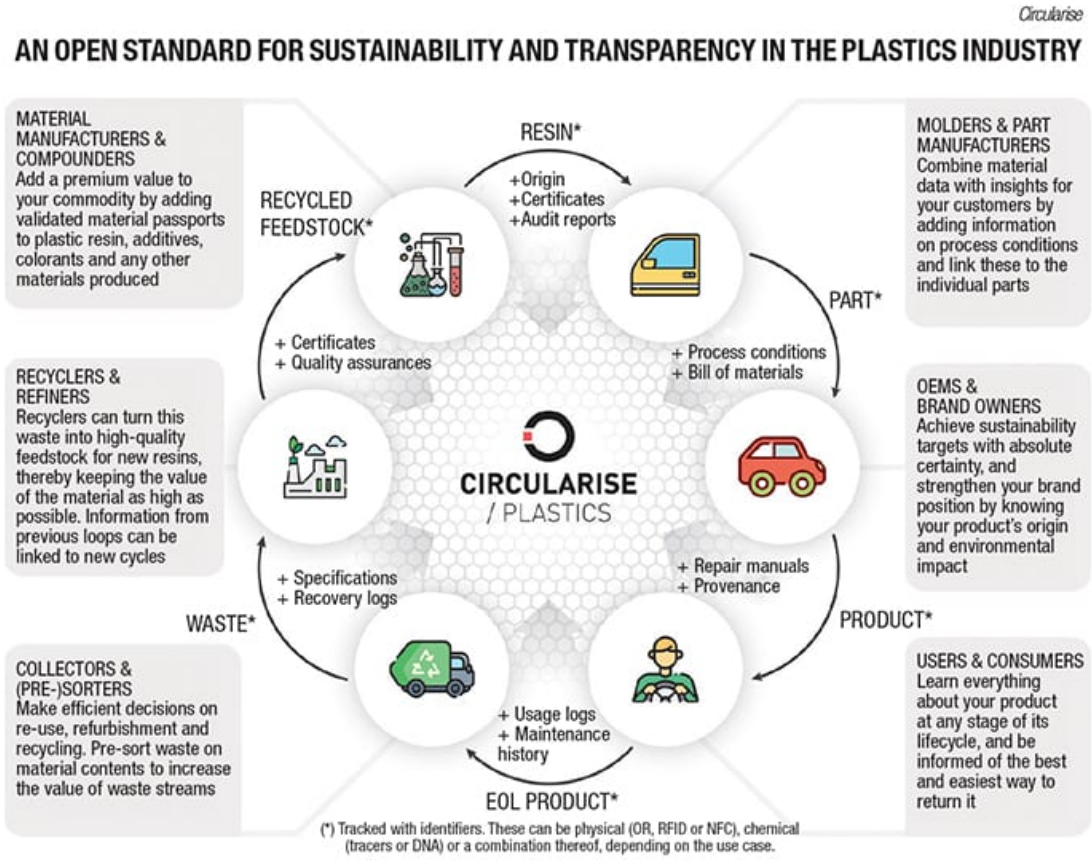
For instance, the Global Battery Alliance has developed guiding principles designed to foster the creation of a sustainable battery value chain by 2030. Key to achieving these goals is the ability to trace materials used in battery manufacturing back to their raw materials and production processes.

Many companies are popping up to incentivize recycling. This is particularly the case for plastic waste that is still not enough recycled.

Circularise - Trusted recycling on the blockchain

Circularise, founded in 2016 in The Netherlands, is a supply chain transparency start-up that helps plastic manufacturers, brands and OEMs to trace raw materials from source, into parts and ultimately to end products. Circularise have built a decentralised and secure protocol for the circulair economy. The technology allows to track recycled material from the point it goes back into the supply chain. The company uses blockchain and other cutting-edge technologies to enable businesses to share data about their products while retaining privacy over sensitive information [15].

To carry a systemic transformation to a circular economy, different actors in the value chain need to cooperate and share information about products, materials and supply chains. This rarely happens because the cooperation among businesses often implies increased risks associated with exposing data. Circularise addresses this issue by building a solution that enables value chain actors to share data without ever disclosing their sensitive information.



An open standard for sustainability and transparency in the plastic industry [16]

ReciChain

BASF also launched a new blockchain for recycling plastics, reciChain. This novel approach to the recycling process involves a series of badges that will help recyclers with mechanical sorting of collected plastics because the badges can be scanned [17]. The result is a more competitive circular supply chain rather than a linear one, extending the lifecycle of plastics. Additionally, due to the increased transparency reciChain brings, the platform can provide better assurance to brand owners of the validity of the certificates they purchase from recyclers and converters.

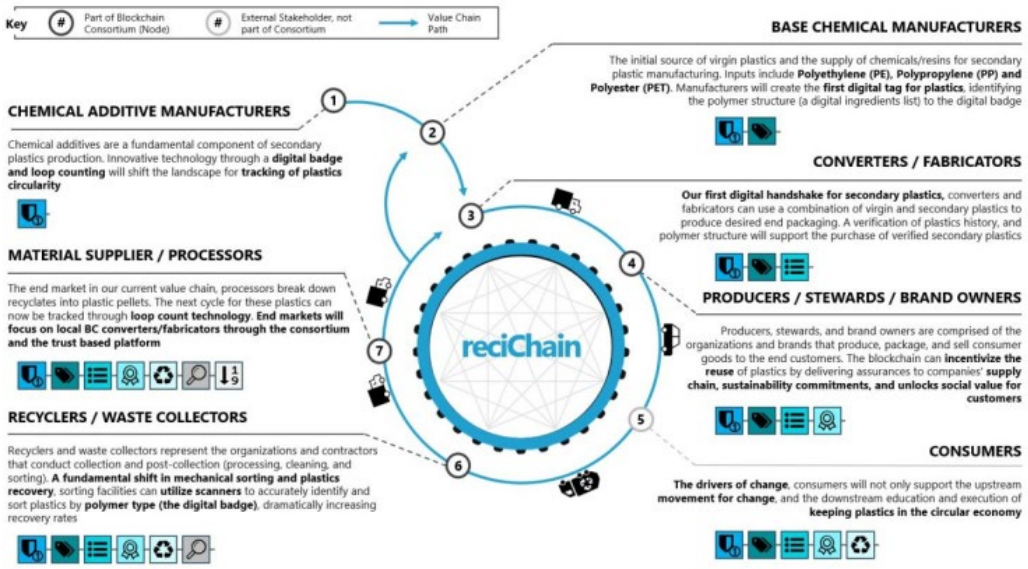


Figure 5 – ReciChain overview [18]

Other initiatives

BASF and Circularise are not the firsts to use blockchain in plastics recycling. Dell laptop owners were already able to view the provenance of recycled materials tracked using VMWare's blockchain technology [19]. PlasticBank is also using tokens to incentivize the collection of plastics and is working with cleaning supplies company SC Johnson [20].

To motivate consumers, a new German Association BIOTA was also formed to incentivize people to collect plastic waste. The project is similar to people being paid for returning glass bottles but uses distributed ledger (DLT) tokens from IOTA.

Use of Blockchain for energy management

Energy management has historically been highly centralized. Transactions in energy must usually go through an established power holding company or deal with a re-seller that buys from an electricity company. As with other industries, blockchains technologies could minimize (or even eliminate) the need for intermediaries.

An interconnected energy system of the future requires decentralised, democratic and resilient electricity trading. Ever more companies are wishing for blockchain technology to become a core feature of the European electricity market. Indeed, the latest achievements in blockchain enable smart contracts that can become a basis of the automated energy trading of the future. Basically, the system can be programmed to buy energy when it costs X euros, and a renewable generator can be set to sell electricity on the grid for Y euros. When X=Y, the smart contract is executed, and the electricity is sold from the renewable generator to the consumer.

The payoff is then potentially huge: homes and businesses could make money by offering their flexible energy resources to grid operators. That would make it more valuable to own such systems and help to increase the overall penetration of renewables. This potential of blockchain for wholesale energy trading has been highlighted in a number of sources, with some consultancy reports [21] even arguing that it has the potential to transform the current energy market structure. However, realising this vision in practice will need to overcome a

number of significant roadblock and technical challenges.

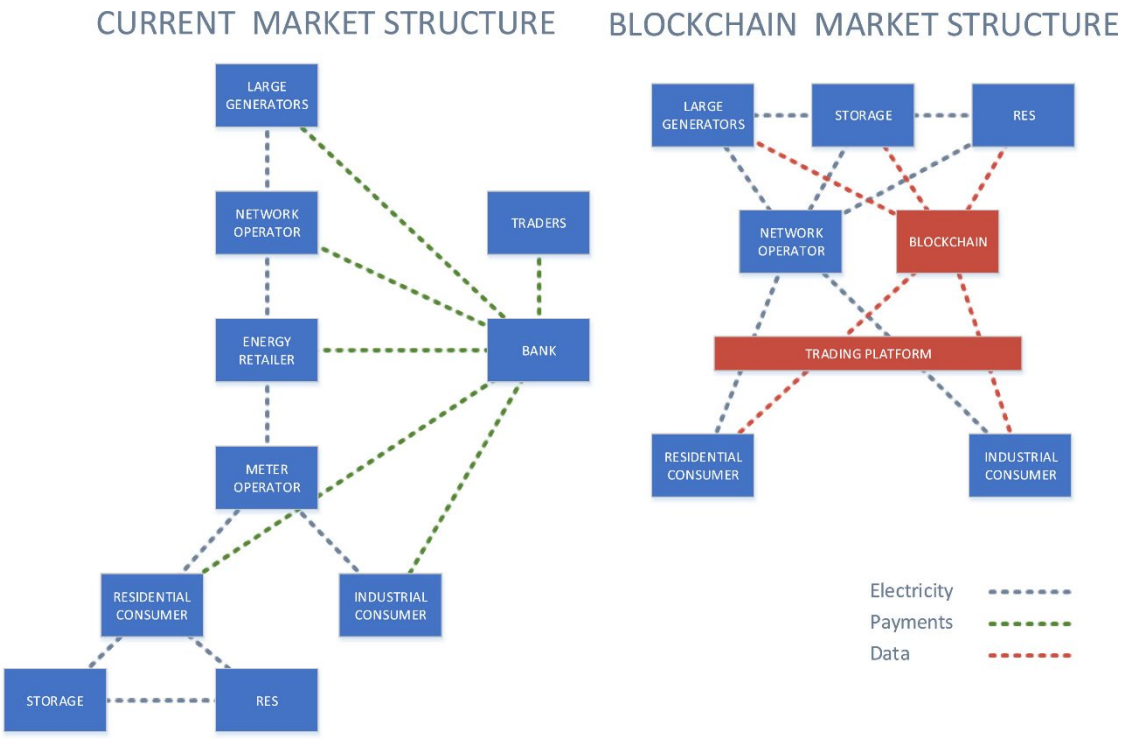


Figure 6 - Transformation of market with blockchains according to PWC [22]

Blockchain technology could be used to execute energy supply transactions but some companies are also using blockchain as a path toward providing access to renewable energy. For instance, two major Spanish power companies — Acciona Energy and Iberdrola — are using blockchain to certify that energy is clean by tracking its origins. [23]. Blockchain technology could provide too the basis for metering, billing, clearing processes, documenting ownership, origin guarantees and emission allowances.

They aim to use blockchain to promote energy-efficient ways of getting around, such as electric vehicles. Then, the blockchain spurs people to adopt eco-friendly, environmentally conscious behaviors that help offset the energy used.

The Equigy Consortium

Major European grid operators are rolling out a new blockchain platform to tap the growing penetration of small-scale distributed energy resources for grid balancing. The Equigy consortium, launched last month, believes blockchain is the key to unlocking such a system. The consortium includes three transmission system operators (TSOs): TenneT (with operations in Germany and the Netherlands), Swissgrid of Switzerland, and Terna of Italy. Denmark's Energinet is in the process of joining, opening the way for initial deployment across five countries. The Equigy consortium will run a free-to-use "crowd-balancing" platform to register and track transactions. [24]

Share&Charge and the Ethereum blockchain

The lack of infrastructure is the main barriers that makes people hesitate to invest in electric cars. Blockchain-based, peer-to-peer platforms exist to help people find private charging stations for their electric cars. Share & Charge, a foundation from Switzerland, leverages the

Ethereum blockchain to connect drivers with charging points. Through the platform, private charging stations can independently determine the charging method and the price of their electricity service, while electric vehicle owners can search for the next charging station on an interactive map [25].

Conclusion

Blockchain has understandably earned a poor reputation due to concerns about its energy requirements. The blockchain could develop a better reputation among people who appreciate its technological potential but have problems with the energy aspect.

But, if running a blockchain has the potential to require a significant amount of electricity, it's important to make the distinction between Bitcoin and blockchain, which has evolved far beyond its original application in cryptocurrency: Bitcoin requires a digital-labour intensive process with excessive energy demands, while blockchain doesn't necessarily. Thus, the most responsible approach to take is to thoroughly research blockchain solutions — and their energy implications — before pursuing them.

Furthermore, blockchain is already starting to be used for environmental applications. Industry players across the world will be keeping an eye on its wide-ranging uses for environmental issues as the technology continues to evolve. Blockchain's ability to provide a verifiable and transparent record may make it well-placed to help address environmental challenges. Use-cases of blockchain for environmental sustainability and natural resources management are rapidly evolving. Blockchain can indeed already be used to track environmental compliance and the impact of agreement, thus decreasing fraud and manipulation. Donations to charities can also be tracked to ensure that they are being attributed efficiently and as planned. Products can be tracked too from origin to source in order to help to reduce carbon footprints, increase ethical accountability and reduce unsustainable practices. As a whole, recycling can be incentivised by offering token rewards to participants and encourage the deployment of the Circular Economy.

Numerous stakeholders will nevertheless need to work together to make the most of blockchain for environmental sustainability and minimise its downsides and risks. Cooperation would also strengthen the chances of success for blockchain applications to support a wider set of socially valuable outcomes, not only those relating to the environment.

Literature

1. O'Dwyer KJ, Malone D (2014) Bitcoin mining and its energy footprint. In: 25th IET Irish signals & systems conference 2014, pp 280–285

2. Stoll C, Klaaßen L, Gallersdörfer U (2019) The carbon footprint of bitcoin. Joule 3(7):1647–1661

3. Sedlmeir, J., Buhl, H.U., Fridgen, G. et al. The Energy Consumption of Blockchain Technology: Beyond Myth. Bus Inf Syst Eng 62, 599–608 (2020). https://doi.org/10.1007/s12599-020-00656-x

4. Rory Carroll, The Guardian, Why Irish data centre boom is complicating climate efforts, 6 Jan 2020, https://www.theguardian.com/environment/2020/jan/06/why-irish-data-centre-boom-complicating-climate-efforts

5. Digiconomist , Bitcoin Energy Consumption Index, https://digiconomist.net/bitcoin-energy-consumption

6. Hasse, F., von Perfall, A., Hillebrand, T., Smole, E., Lay, L. and Charlet, M. (2016) Blockchain – an opportunity for energy producers and consumers. London: PricewaterhouseCoopers Global Power & Utilities, www.pwc.com/gx/en/industries/assets/pwc-blockchain-

opportunity-for-energyproducers-and-consumers.pdf

7. Ameer Rosic, Proof of Work vs Proof of Stake: Basic Mining Guide, https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/

8. BioAge Group, Trial of next-gen blockchain solution shows increased speed and energy efficiency; Red Belly Blockchain, 2018, https://www.greencarcongress.com/2018/09/20180925-redbelly.html

9. Pisa, M. (2018) 'Reassessing Expectations for Blockchain and Development' Innovations: Technology, Governance, Globalization 12(1–2): 80–88, www.mitpressjournals.org/doi/pdf/10.1162/inov_a_00269

10. M. Denis Le Sève, N.Mason and D.Nassiry, Delivering blockchain's potential for environmental sustainability, October 2018

11. Anne-Titia Bové and Steven Swartz, Starting at the source: Sustainability in supply chains, 2016, https://www.mckinsey.com/business-functions/sustainability/our-insights/starting-at-the-source-sustainability-in-supply-chains

12. Wikipedia, https://en.bitcoinwiki.org/wiki/Poseidon_Foundation

13 Corporate web site, https://rainforestfoundation.org

14 Corporate web site, DRIFE. Technologies, https://www.drife.one

15 Corporate web site, https://www.circularise.com

16 Mary Page Bailey , The new era of sustainable supply chains, https://www.chemengonline.com/new-era-sustainable-supply-chains/

17 BASF, Corporate web site, https://www.basf.com/ca/en/who-we-are/sustainability/Sustainability-in-Canada/reciChain.html

18. BASF, Envisioning Plastics Circularity, https://www.basf.com/ca/en/who-we-are/sustainability/Sustainability-in-Canada/reciChain.html

19. Ledger Insights, Dell using VMware's blockchain to track recycled packaging, https://www.ledgerinsights.com/dell-vmware-blockchain-recycled-plastic/

20. https://www.ledgerinsights.com/sc-johnson-plastic-bank-blockchain-tokens-plastic-pollution/

21. Merlinda Andoni, Valentin Robu, David Flynn, Simone Abram, Dale Geach, David Jenkins, Peter McCallum, Andrew Peacock, Blockchain technology in the energy sector: A systematic review of challenges and opportunities, Renewable and Sustainable Energy Reviews, Volume 100, 2019, Pages 143-174, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2018.10.014.

22. PwC global power & utilities, Blockchain - an opportunity for energy producersand consumers?. ⟨https://www.pwc.com/gx/en/industries/assets/pwc-blockchain-opportunity-for-energy-producers-and-consumers.pdf⟩, [accessed 22Nov 2017] (2016).

23. CB Insights, Banking Is Only The Beginning: 58 Big Industries Blockchain Could Transform, 2020, https://www.cbinsights.com/research/industries-disrupted-blockchain/

24. Equigy, Coporate web site, https://equigy.com/