EU Blockchain Observatory and Forum

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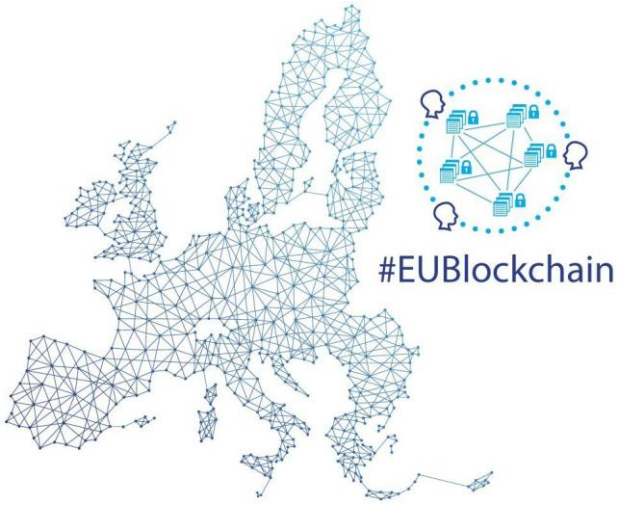
EU BLOCKCHAIN OBSERVATORY & FORUM

Workshop Report –

Energy Efficiency of Blockchain –

Online Video Conference, 21st of April 2021



By the European Commission, Directorate-General of Communications Networks, Content & Technology.

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WELCOME

Ioannis Vlachos, EU Blockchain Observatory and Forum, commenced the workshop with a brief explanation on the housekeeping rules that had to be followed during the workshop.

Peteris Zilgalvis, Head of Unit, Digital Innovation and Blockchain, DG CONNECT; Co-Chair, FinTech Task Force, EC followed, welcoming everyone to the workshop on energy efficiency of blockchain. He mentioned that part of the theme of the workshop is how heavy is the environmental impact of Proof-of-Work and made reference to the European Climate Law that was adopted on April 21, 2021, the first law, aiming for Europe, the economy and society to become climate neutral by 2050. There is a new EU target for 2030 of at least 55% reductions in emissions compared to 1990 and the European Commission has proposed to include the new EU 2030 targets in the law. Lastly, he mentioned that when promoting the utilization of the European Blockchain Services Infrastructure climate and energy implications have to be taken into consideration.

PRESENTATION OF THE "EXPLORING ENERGY EFFICIENCY OF BLOCKCHAIN TECHNOLOGY" THEMATIC REPORT

After the welcoming to the workshop, the floor was given to **Mr. Ioannis Vlachos,** Energy Markets Expert of Energy Web, who presented on behalf of the EUBOF consortium, the upcoming energy efficiency report which has been written relying on the expertise of the members of the EUBOF expert panel, academics and C-level executives from reputable companies worldwide and on interviews with industry experts.

He then went on to explain in detail the Table of Contents of the report:

- Chapter 1 focuses on demystifying consensus protocols (general presentation of the Byzantine Fault-Tolerant systems, consensus mechanisms and blockchain types) and on the issue of comparing some of across the several consensus protocols or mechanisms, like proof of work, proof of stake, a delegated proof of stake, proof, authority, and other types of consensus protocols or mechanisms.
- Chapter 2 offers an overview of the cryptocurrency and mining industry (overview of geographies, issues related to limitations on local or regional regular frameworks related to cryptocurrency mining industry) and of the energy resources that are used for mining operations, as well as an analysis on the profitability of these mining operations.
- Chapter 3 discusses the Bitcoin Energy Consumption Index, and specifically two approaches: a)the Cambridge Bitcoin Electricity Consumption Index and b) the Digiconomist Bitcoin Energy Consumption Index
- Chapter 4 tackles the issue of blockchain performance and if blockchain based solutions, can actually scale and perform in a commercial setting. The chapter includes a comparison of the various blockchains, and a comparison of the infrastructure that is used for cryptocurrency mining.
- Chapter 5 focuses on scalability and performance considerations, specifically on the challenges faced by various sectors such as fintech and energy, and on the approaches to overcome these scalability and performance barriers.
- Chapter 6 is focused on decarbonization initiatives for the blockchain sector and provides an overview of the Crypto Climate Accord initiative.

BEYOND PROOF-OF-WORK: ENERGY CONSUMPTION OF BLOCKCHAIN SYSTEMS

Mr. Gilbert Fridgen, SnT, Interdisciplinary Centre for Security, Reliability and Trust, University of Luxembourg started the presentation by explaining that a consensus mechanism is basically an algorithm that makes sure that all participants on a given blockchain reach a consensus about what is the truth. There are different consensus mechanisms that are used in different settings. The consensus mechanism for Bitcoin is called Proof-of-Work and Bitcoin makes it extremely complex in terms of calculations and energy required to add another block to the blockchain or attack the immutability of Bitcoin. The Ethereum blockchain is another blockchain solution which uses Proof-of-Stake and does not rely on this extreme energy consumption of these extreme calculations. It requires a deposit and if someone tries to forge something then the deposit is lost which makes it economically unattractive to attack the network. Another solution is used by Hyperledger and it's called Proof-of-Authority.

He then referred to Distributed Ledger Performance Scan (DLPS), a tool that analyses data, difference technologies' features about which technology is most suitable for each use case. The development of this tool is ongoing and an open source has also been published on GitHub while research focuses on quantitative questions such as how much transactions per second can have a certain technology bear. The tool has been implemented for different blockchain technologies since there is a standardized procedure where each blockchain gets a standardized test which reveals the throughput.

The tool shows the energy consumption per transaction for different architectures so this notion of blockchain being perceived energy inefficient, it's wrong because there are different ways to implement it. He went on to explain that the European Blockchain Services Infrastructure has the objective that the system shall not have a consensus mechanism based on Proof-of-Work because this creates too much energy consumption.

Mr Fridgen referred to the recent incident of the Suez Canal being blocked for six days and how a ship in a harbour consumes 1 billion joules per second. He compared TradeLens, an open supply chain platform underpinned by blockchain technology, built by IBM and Maersk to manage the documentation around container shipping, based on the blockchain technology they used and found that the total energy consumption per second of this solution, is still a hundred times smaller than just one ship waiting in a harbour. Each container creates a huge pile of documents and although the data are not original this is a good example where it's obvious that blockchain is not necessarily only a solution that costs energy, but if used in the right way, it might even save a lot more energy than it costs.

PANEL DISCUSSION 1: ENERGY CONSUMPTION OF BLOCKCHAIN: MYTHS vs REALITY

Moderated by Irene ADAMSKI, Co-chair Working Group Energy, INATBA

- **Marianna BELOTTI**, Caisse des Dépôts Group and Co-chair of the Governance Working Group at INATBA
- **Alex de VRIES**, Digiconomist
- **Alexi ANANIA**, Research Coordinator, Cambridge Centre of Alternative Finance
- **Marco LOPRIENO**, DG CLIMA

Objectives of the session:

- Different aspects of energy consumption

- DLT beyond Bitcoin and use cases to implement blockchain
- Societal net gains and net loss from the usage of DLT and blockchain
- Using renewable energies for mining

Main outtakes from the session:

Initially, the moderator, **Ms Irene Adamski**, presented the panellists and explained that the panel's main topic will be the different aspects of the energy consumption perspective such as the political perspective and the actual consumption of blockchain.

- **Mr Marco Loprieno,** took the floor explaining his hopes for the use of DLT and blockchain for the purpose of climate action. He referred to the great deal of hope there is in recognizing the potential of DLT and especially in such a complex framework, such as the European Climate policy development and implementation and that according to the first agreement on the climate law, the goal is to fully de-carbonize the overall society in the EU by 2050.
- **Ms Marianna Belotti,** followed expressing her views on the aspects that one should keep in mind when looking at the discussion of energy consumption. She also agreed that the Proof-of-Work does not represent the overall consensus world, and that different consensus schemes exist and have been proposed to solve the energy issue problem. She referred to the evolution of consensus, which started with Bitcoin proposing a new paradigm of reaching a consensus that was consuming energy to source something new and that new schemes had to be created to resolve this problem. The different mechanisms to build different blockchains that can consume less energy are based on past consensus mechanism and protocols. Ms Belotti mentioned that when it comes to different use cases, the benefits of each type of blockchain need to be analysed and which consensus mechanism needs to be used depending on each specific use case.
- **Mr Alexi Anania,** joined the discussion by describing how the various use cases are different on a structural level, both architecturally and as a mechanism design. Bitcoin uses a blockchain structure, which is a single linear chain replicated over many nodes which means that each block needs to wait for the previous block to be validated and verified. There is also an attempt to distribute this transaction validation process. When there's low transaction volume, understandably because of the architecture, the network is slowest and most vulnerable to attack. While there are multiple DLT systems each one has its specific advantages and disadvantages, and it ultimately depends on the use case and expected environment. It's not really a winner takes all situation, but rather which DLT is better, which infrastructure is better suited to the specific use case.
- **Mr Alex de Vries** took the floor and referred to the various ways to estimate the energy consumption of Bitcoin network like looking at the total computational power in the network and trying to figure out how that breaks down. That's a hard way because the breakdown is not visible, so an assumption needs to be made on what machines are in the network and estimate how much energy is being used by the network. There's only a limited selection of machines one can use and there is a device that is the most efficient at mining. By multiplying the network's computational power with the efficiency of the most efficient device available at the moment, one can come up with a lower bound for the network. Another way of doing it, is to look at the amount of money that's being earned by the miners. That's an observable number and can then try to figure out how much of that is being spent on electricity and come up with an estimate based on that. According to Digiconomist, Bitcoin network is consuming as much electrical energy as half of the world's data centers, as 100 TWh, but according to Cambridge Electricity Consumption Index, it's around 120 TWh which is close to a country like Argentina. In any case it is around a half a percent of the global electricity consumption. Another thing to look at is how

dirty is that energy, where is it coming from or being sourced from and there is the assumption that large part of that is being sourced from China, specifically the North of China. According to Digiconomist, the carbon footprint of the Bitcoin network is about the same as a country like Hong Kong. It's always hard getting the right perspective, but everyone agrees that Bitcoin is still very small today as it's not adopted by everyone. However, it already consumes half a percent of global electricity and can go a lot bigger than that.

- On a follow-up question by the moderator in regard to what use cases would make sense to use blockchain to keep it in perspective, **Mr Alex de Vries** replied that a lot of things can be done with this technology as it embeds trust in the system, and allows for intermediation, if, for example, a (any) government starts issuing a Central Bank Digital Currency, here we can see some level of banking intermediation, and that is regardless of what type of blockchain – they will probably won't even be using a blockchain to do that. It really depends on what one wants to achieve; the key takeaway is that the technology can be used to build trustless systems, beyond Bitcoin.
- On a question from the audience, whether Europe should do something to defend rights of European citizens in participating in future retail markets by ensuring appropriate amount of Bitcoin nodes being located in Europe despite high energy consumption, **Ms Marianna Belotti,** replied that the centralization in the mining procedure right now is based on cost reasons. Although there is currently a rebalancing of the centralized industry that was in China and now is more Baltic oriented, miners are driven by incentives, they mine where they gain more so there is not much to be done; it is based on the cost of electricity.
- On that same question, **Mr Marco Loprieno** said that in geopolitical terms there is not something to be done to protect Europe's own approach to blockchain or Bitcoin without involving China in the process. It's a very complex policy tool that is coming to life. In addition, monitoring data in China is a difficult issue, China is so advanced at a certain extend but it's kind of a fragmented country because of the different provinces that are more advanced, or less advanced socially, economically and technologically.
- On a question about the societal net gains and net loss that a usage of DLT and blockchain can bring, **Mr Alexi Anania** replied that on the net gain side, when compared to traditional centralized ledgers, proponents of DLT, typically highlight the utility of decentralization has governance or disintermediation whereby removing the intermediate intermediary leads to cost reductions or greater transparency, which leads to easier auditability. The automation and programmability are also significant, more relevant to smart contract enabled blockchains or DLT systems. At the other end of the spectrum the net losses or disadvantages and risks would probably be in the roles and responsibilities of stakeholders whereby stakeholders that had a specific role in a traditional financial sector, may be redundant or less useful on a DLT system. There are also substantial costs related to migrating the existing IT systems to DLT based infrastructures. These DLT systems often created for financial inclusiveness, or just for inclusiveness in general, and often there's this unintended exclusivity that's caused by the steep learning curve be that participants need in its current to have a specific skillset to interact with the underlying infrastructure. There are also frictions such as with the case of public blockchains that transactions are irreversible or deterministic, which doesn't help very much in the case of fraud or human error.
- On another question about using renewable energies for mining, **Mr Alexi Anania** mentioned that it's not about the amount of energy consumed but about the amount of clean energy that is consumed. It's not a bad thing to consume energy since it's there to be consumed, it only means that technology is evolving, as long as this is clean energy.
- **Ms Marianna Belotti,** pointed out that the technological ecosystem should address the problem of energy, considering the fact that there is experience in using green energy. It's important for

each business case to focus on the type of blockchain, the benefits and the energy consumption level before choosing the appropriate consensus mechanism.

- **Mr Alexi Anania,** concluded that the tremendous rate at which the industry grows on multiple levels, starting from the very technical base layer, all the way out to the stakeholder positioning is insane. The end goal was always to create the sense of financial inclusion so Decentralized Finance or DeFi is the final building block toward this financial freedom and a collaborative capitalism. DeFi comes with a plethora of opportunities such as decentralized exchanges, stable coins and lending platform.
- **Mr Alex de Vries,** in his final remarks mentioned that it's not just about energy consumption when it comes to Proof-of-Work blockchains, it's also about material usage; more than a billion chips are needed to satisfy the demand of Bitcoin miners let alone the graphic cards for Ethereum miners and other cryptocurrencies. In addition, there is the issue of electronic waste partially from the machines themselves
- Lastly, **Mr Marco Loprieno**, on an optimistic and collaborative note, mentioned that decarbonization should be achieved not only in the EU but in the whole planet by 2050. There are of course a lot of geopolitical implications, but fossil fuels should not be used anymore, they should be left in the air.

PANEL DISCUSSION 2: DECARBONIZING THE BLOCKCHAIN

Moderated by Ioannis VLACHOS, INTRASOFT International

- **Walter KOK**, CEO, Energy Web
- **Jo Ann BAREFOOT**, CEO, Alliance for Innovative Regulation
- **Bharath CHARI**, Co-founder, XRP Ledger Foundation
- **Mark CACHIA**, CEO, Scytale Ventures

Objectives of the session:

- Familiarize the public with the definition and ways to decarbonize the blockchain,
- Showcase the impact and benefits of decarbonization,
- Allow different sectors to talk about the environmental and social impact,
- Incentivize stakeholders to consider participating in cooperative actions.

Main outtakes from the session:

The session moderator was **Mr. Ioannis Vlachos**, who introduced the speakers to the audience. The discussion format was shaped around the moderator posing two questions to each speaker in a circular order. The panel concluded with a question from the audience that each speaker had the opportunity to discuss.

- The initial question posed to **Mr. Walter Kok** was about the goal of Energy Web and the way to make the crypto world greener. The speaker has pointed out the existence of numerous opinions on energy usage in every sector and that Energy Web is a member-driven organization with its main objective be to gauge how green is a grid. With this goal, the organization expanded into the crypto world. Blockchain is a technology that will not cease to exist as it solves problems and inefficiencies. For instance, blockchain can facilitate a decentralised model that could give the power back to the public and remove third parties. Communities are active around cryptocurrencies as numerous protocols are developed and companies are introducing cryptos to their balance sheets as a mean to hedge inflation. All this activity calls to address issues in the crypto world and rally the sector into the future. Energy Web dedicates efforts to make the crypto sector friendlier to the environment. These efforts have produced the Energy Web Zero platform that offsets the carbon footprint of mining and transacting in the crypto sector. A fundamental idea for the platform is that crypto and its mining is not dissimilar to traditional IT services and should be as green as possible.
- The following question was on the **Ms. Jo Ann Barefoot** view on the CCA's legislation side on the crypto climate accord. There is optimism in blockchain as the potential to improve the financial system exists. As the work on blockchain is developed and the sector comes closer to the mainstream, the legislators' interest will be drawn to the sector. Another market factor is that the US with its new government is expected to put effort into green activity. As part of AIR, the speaker referred to the organization's objective. that is to assist the regulatory sector to keep up with technology. The regulatory bodies are not equipped to handle the pace of the changes, so the need is to help them in handling the changes without quashing innovation or freely allowing bad things. As cryptos become more mainstream and attract more people, there is a case of misunderstanding around the technology and people getting hurt from cryptos. With this in mind, a heavyweight of regulation will follow.
- **Mr. Bharath Chari** had the floor to answer the question on the XRP foundation's views on initiatives about blockchain decarbonization. The foundation believes in technology and its

prosperity, so it is consequently interested in decarbonization. A core mission for the foundation is to alleviate financial and social inclusion. The mean to achieve that mission should be taken into account too. The mean has to be beneficial in the overall context and not at the expense of the environment. A greener blockchain is a non-partisan objective, as it can leave a legacy on the way that the financial world regards the crypto sector. The projects have to be efficient from a trustless and cost point of view, but other aspects also have to be considered. Furthermore, partnerships and dialogue are important as the sector attracts stakeholders outside of the crypto sector and will start investigating issues like the blockchain's environmental friendliness. Small payments can be difficult to scale up, as the associated cost is closely related to energy and can make them prohibited. It should be noted in the environmental issues, everyone is affected. So, blockchain should strive towards being greener like any other machinery. In his closing remark, the speaker pointed to challenges in the blockchain and their possible solution. The possible solution was for the stakeholder to come together and be responsible players.

- **Mr. Mark Cachia** has shared his view on the impact that sustainability has on investing in blockchain. Profit was combined with the social impact in the investing mandate. A positive social impact makes it easier to attract investments, as investors look for projects with positive social impact. Initiatives like Energy Web are valuable for providing ways towards gauging the impact. As an example, the Proof-of-Work blockchains have been briefly discussed. While that particular consensus algorithm secures the blockchain, it is not efficient in energy usage.
- In the second round of questions, **Mr. Walter Kok** presented the purpose of the platform that was developed by Energy Web. Energy Web is a proof authority, it was established to build a digital open-source infrastructure for decarbonization. So, blockchain was a logical sector to put effort into. The platform, Energy Web Zero, was launched the previous year as a way to offset the carbon footprint of the electricity consumption of cryptos. The platform accounts for both of the market, supply and demand, in order to be usable. The source of the energy used in the blockchain's hash rates and consensus algorithms could be monitored to value the degree of environmental friendliness. On the demand side, stakeholders like investors, exchanges, and mining facilities can have the option of offsetting carbon footprint. Carbon offsetting is possible by making use of sectors that are in a regulated framework that allows the traceability of the energy source.
- **Mr. Bharath Chari** talked about the plans relevant to carbon that XRP foundation has set to achieve by 2030. There should be a commitment to goals, as they are not achieved in a short period. The XRP is in a different place due to the underlying consensus algorithm that is not becoming harder to solve. Another advantage for XRP is the use of commodity machines and servers. In conjunction with the use of commodity machines, the foundation aims to be efficient in the code to allow run on more efficient systems. An intriguing fact for moving into the future is that countries with renewable energy sources available can harness blockchain and its benefits. A closing remark is that the participation of all the members is the key to a greener blockchain.
- **Ms. Jo Ann Barefoot** was challenged to present the barriers that might be in place to convince the crypto world to move towards greener policies. People have considerations about blockchain use, but they might not grasp the opportunities that exist in the technology. Climate accords can help in filling that gap with public education. A concern that is present in any financially motivated enterprise is the high cost of operation and conversation to new technology. Another concern has to do with the fear that projects like XRP, that voluntary venture into moves, put themselves to a disadvantage compared to the overall market. Cooperative approaches can mitigate these concerns, as the burdens can be divided into the participants. Some people have not looked into the crypto sector future. In particular, people are underestimating the regulations that are imminent to be set. Actions that are taken at present as a proactive measure can stir up the ire of political leaders and regulators towards a business-

driven approach. Public trust is essential for the wide use of the technology, as consumers and investors prefer to be associated with companies that do the right thing. A final remark was that blockchain is at the early stage of the industry itself and the future ahead calls for good reputation and high trust in the whole sector.

- **Mr. Mark Cachia** provided his view on the investment attractiveness of blockchain projects with greener policies and the degree that social responsibility has a role in investment attractiveness. Mr Cachia has admitted that both, environmental friendliness and social responsibility, are factors in investors' decision. Blockchain technology is not limited to cryptocurrencies, but it is applied in a wide range of use cases. The situation in ESG reporting was an example to showcase the mess that exists. Huge corporates are the only stakeholders that get the guideline right, but they have difficulty in meeting the necessary numbers. While there are choices in self-reporting, there is a lack of options in verification and authentication. Platforms like Energy Web Zero can assist in reporting energy usage efficiently. Transparency can be vital in building trust in the technology, and platforms can play a role in transparency. Mr Cachia is excited about the technology, as he considers it to be a core in the future.
- Finally, the panel participants provided their insights on how the use of blockchain solutions may not solve the problem for a more sustainable crypto world taking into account the limited or underdeveloped available choices like guarantees of origin and renewable energy certification.

PANEL DISCUSSION 3: CAN BLOCKCHAIN SOLUTIONS SCALE? TALES FROM THE INDUSTRY

Moderated by Arno LAEVEN, Co-founder, WBNoDE

- **Nik SCHARMANN,** Project Director "Economy of Things", Bosch
- **Barbara HANNA,** Delivery Manager IoT, Vodafone Business
- **Micha ROON,** CTO, Energy Web

Objectives of the session:

- Discuss the main reasons why blockchain solutions don't usually scale up
- Provide views from the industry on solutions that actually do scale
- Share relevant experiences from key industrial partners

Main outtakes from the session:

Mr. Arno Laeven, the session moderator, introduced the session explaining that the panellists will be invited to talk about aspects of scalability and interoperability concerning blockchain as well as different types of solutions, taking a more interdisciplinary approach addressing social, organisational, legal and maybe even ethical perspectives. Each of the panellists was then given the floor to introduce themselves and their organisation. Then they were asked to answer on whether energy consumption and energy efficiency is a topic of concern and discussion within their organisations.

- The first question posed to the panellists was on the possibility that the energy consumption of blockchain is a topic discussed in their entities and is regarded as a hurdle. Ms. **Barbara Hanna** explained that blockchain energy consumption and efficiency is indeed a topic of discussion within Vodafone. Renewable energy is one of their objectives as a way of doing the right thing for the planet. The objective is carried on the cooperative actions with partners, where areas can be identified as points of concern or points that need to be solved in a holistic perspective. Mr. **Nick Scharmann** was the next to add his opinion. He stated that Bosch puts efforts into operating in the economy of things and blockchain is an instance of decentralized technology. Blockchain practitioners are bound to stumble on the energy consumption issue of the Proof of Work mechanism. But the practitioners should be discouraged, as a mixture of different means exists to mitigate that problem. The existence of different consensus algorithms and the use of technologies as second layer solutions are some of the examples of mitigating that. Finally, Mr. **Mich Roon** elaborated on the way that Energy Web is energy efficient. Energy consumption is always an issue of greenhouse gas emissions for its production.
- The next question that Mr. **Arno Laeven** brought into the conversation was on the possibility that technical scalability could be one of the main hurdles. Mr. **Micha Roon** was the first one to express his mind. He acknowledged that the technology is not yet mature enough. He compared the overall blockchain scene to the situation that the database was in the 90s. The intelligence and tools that have yet to be developed are missing parts for scaling blockchain. Blockchain has introduced mechanisms like sharding and layer-two solutions as an initial step. There are market solutions such as the Avalance protocol and blockchain that have handle transactions in parallel instead of in sequential order. Mr. **Nick Scharmann** agreed with Mr. Micha Roon's summary and added that scaling is a diffusion issue as well. In the hypothetical scenario of a perfect blockchain system, the incumbent industry in Europe will still have problems in adopting that system. This belief stems from the lack of mindset and technological know-how on

blockchain. Blockchain is out for some years, but the classic engineering industry and automotive industry in Europe has yet to grasp the technology's potential. Moreover, the concept of cooperative data spaces would be introduced in the future. Initiatives like "Gaia-X" exist to research ways in cooperative data spaces. Europe has noticed that the data sovereignty and decentralized platforms are messing well together. Finally, Ms. **Barbara Hanna** referred to the increased need for decentralized assets. Vodafone as IoT and communication provider will work to bring solutions to these issues. The company can provide the expertise in securely communicating devices based on SIM technology in cooperative actions. Technical scalability is more appropriately solved during convergence. It should be noted that during convergence people from different sciences and backgrounds are coming together to complete the project and share their ideas.

- The next question was on the social approach and what do you see as a scalability issue in the social domain. Mr. **Nick Scharmann** has brought up the project Gaia-X which is supported by the European Commission and companies. Bosch along with other partners have introduced decentralized technology in the project. For instance, a sensor identity has been planned successfully as the basic architecture system. In the future steps, more complex technologies will be introduced gradually. In other words, the addition of specific solutions to the system as a whole will gradually increase the decentralization.
- Mr. **Arno Laeven** shared a question by the audience about the junction of identity protocols with Energy web's footprint measurement and if such an approach will call for a bridging protocol like Polkadot. Mr. Micha Roon shared his answer to that question. The first comment was that the approach in the identity should be open and there are collaborations like ID Union that works on developing methods. He clarified that the Energy Web chain is a trust layer of the energy web decentralized operating system and that the footprint measurement with the certificate is only one of the use cases. Energy Web is not part of the Polkadot ecosystem, but efforts in integrating anything with Polkadot are constantly being made. Due to the finality of Energy Web chain, it is possible to bridge the chain with the use of an interblockchain communication protocol.
- Mr. **Nick Scharmann** was asked about the interoperability issues in the technical integration. He stated that the ID Union is an initiative that the cooperative data space is present, and discussions are held on asserting the interoperability of the network. The subject of interoperability in projects comes naturally once there is a certain degree of maturity. On the other hand, there are initiatives such as Gaia-X and Katrina-X that are not ready for interoperability as participants are not advanced to discuss interoperability.
- Ms. **Barbara Hanna** has discussed scalability and interoperability as part of a leading provider of IoT connectivity. Scalability involves various dimensions that should be considered such as the regulatory landscape, technical difficulties, the use of the right devices and their certification, and many more. Initiatives with blockchain based on SIM-centric approaches may secure the IDs of assets and allow secure connectivity. In cooperative actions, there is the chance to push partners towards solving the most important problems.
- The following question was the impression that assets and IoT devices seem to be easier to scale in blockchain projects and the ID especially seems to be such a use case. Mr. **Micha Roon** stated that IoT integration can be easier due to the existence of a single interface. IoT devices have only one SIM card which holds its private key making the private key management smoother and straightforward. In contrast, humans are operating in a range of devices including smartphones and laptops. The case for humans is a nightmare, as the different devices have to be accounted for. Moreover, humans tend to be forgetful, while this is not possible with IoT devices. Despite all the difficulties, it is important to provide humans with a decentralized identity. A decentralized identity can be a solution to data silos and prevent data leakage scandals. Mr. **Nick Scharmann** has pointed that digital identity is the use case that gains most

traction in the classic industry. Despite the speaker's initial personal interest in smart contracts, identity is one thing that senior managers easily grasp.

- The next subject was the SSI mechanism in Gaia-X and the hurdles in scaling the solution. Mr. **Nick Scharmann** commented that decentralization is not a Nash equilibrium as in game theory. In Gaia-X, there are companies interested in using cooperative data space, but they fear the existence of control points. The common understanding in SSI helped in using the technology. The idea is depicted in the architectural project view allowing the potential scale-up.
- The next discussion subject was on the starting point for new operating systems that are ambitious. Mr. **Micha Roon** affirmatively pointed to the identity subject as the entering and starting point of a system. The first step is authentication, where you define the user identity. The following step is authorization where users request permission and a decision is made to either grant or deny access to the user. A combination of the SSI concept with the authorization concept is possible to verify in a decentralized manner that the credentials that a user holds have been given correctly to him/her. The term "correctly" is defined in every application and project. Once authentication and authorization processes are in place, functionality can follow. The efficient handling of authorization keys and the communication of devices with the network in a decentralized and secure manner are the points to focus on next. Applications are on top of all these concepts in the architectural view and are relying on them.
- The next question was concerning the potential and unidentified consequences of scaling. Mr. **Micha Roon** hid caution in the creation of control points in the network as openness of the system and its protocols and standards are vital in operating in an open-source mindset. Blockchain tends to create big networks, so avoiding an entity controlling such a network is vital the prosperity of blockchain. Ms. **Barbara Hanna** added that there is always tension in allowing a novel technology to flourish and be optimal in order to live up to the public's expectations. Privacy and adherence to laws are matters that are handled in technology projects. Questions that need to be answered are the problems that should be solved, the consequences of the implemented solutions, and the way that the technology serves societal problems. Finally, Mr. **Nick Scharmann** shared his views on the question. There is a chance that blockchain may be a victim of its own success as states and regulators are interested in touchy subjects such as decentralized identity. In the identity paradigm, governments see benefits in self-serving identity. But, some degree of control has to be secured for states to provide identity for citizens.
- The panellists were challenged by the audience on the possibility of sacrificing part of decentralization for scaling. Mr. **Nick Scharmann** pointed to the two dimensions of decentralization. These dimensions are technical decentralization, which refers to the system itself and its ability to operate in a decentralized manner, and network governance. These are two extremes on each side of the scales. The first one is when you have the perfect governance of a database or a platform, where there is the perfect social choice function where everybody can influence the operation, this is an extreme case where you don't need technical decentralization. On the other hand, you , when you have a super decentralized technology, this may result in little need for governance to keep it that way. The truth deducted out of the two examples indicates is in the middle and good governance can allow some room to ease on the technical decentralization. Mr. **Micha Roon** commented that there is no need to sacrifice decentralization to scale. Tools are developed to create a fully decentralized infrastructure that does not require any real governance and operates freely. Some elements will always necessitate a degree of control in services. For example, banks will not serve customers like money launders who go against the bank's principles. Despite the need for governance, the necessity of a decentralized system is not diminished. In a decent system, authorization can incorporate these concepts to determine that only KYC users can access the service, but anyone can run it.

- The following question was if the type of blockchain (public, private, hybrid) influences scalability and energy consumption. Mr. **Micha Roon** stated that private blockchains are not that meaningful. The interactions between two entities do not call for decentralization. The distributed ledger allows the exchange of information between two entities and makes sure that they share the same information with a notary in-between. The notary can be public like R3 Corda. Mr. **Nick Scharmann** commended that the discussion should not be about the type of blockchain (public, private or hybrid) and it may be better to investigate the different consensus mechanisms. Apart from PoW and PoS, alternative consensus algorithms have to be searched.
- The final question was on what should be considered a successful adoption in a year. Mr. **Micha Roon** provided quantitative results as he mentioned the appliance in a network of 2 million IoT devices and 1 million people scattered in 5 national applications. Ms. **Barbara Hanna** commented that it is too early for an answer and that Vodafone will cover it in a report. Mr. **Nick Scharmann** hoped to see initiatives like ID Union to be legally compliant identity systems.

Appendix

Workshop slides

- Beyond Proof of Work – Energy consumption of blockchain systems
- Energy Efficiency of Blockchain_EUBOF Thematic report sneak preview

Workshop videos

- Videos from this and all other workshops can be found on the EU Blockchain Observatory and Forum website under the section Reports
- Videos specific to this workshop: Energy Efficiency of Blockchains workshop recording

Official agenda

Time	Activity
14:00	**Opening of the session & house rules,** *Ioannis Vlachos, EUBOF*
14.05	**Welcome,** *Pēteris ZILGALVIS, Head of Unit, Digital Innovation and Blockchain, DG CNECT*
14.10	**Presentation of the "Exploring Energy Efficiency of Blockchain Technology" thematic (Presentation on the working methodology and key findings),** *Ioannis VLACHOS, EUBOF*
14.20	**Beyond Proof-of-Work: Energy Consumption of Blockchain Systems,** *Gilbert FRIDGEN, SnT – Interdisciplinary Centre for Security, Reliability and Trust, University of Luxembourg*
14.30	**Panel Discussion 1 –*Energy consumption of blockchain: Myths vs. reality*,** *moderated by Irene ADAMSKI, Co-chair Working Group Energy, INATBA* • Marianna BELOTTI, Co-chair Governance Working Group, INATBA • Alex de VRIES, Digiconomist • Alexi ANANIA, Research Coordinator, Cambridge Centre of Alternative Finance • Marco LOPRIENO, DG CLIMA
15:20	**Panel Discussion 2 – *Decarbonizing the blockchain*** *moderated by Ioannis VLACHOS, Energy Markets Lead, Energy Web* • Walter KOK, CEO, Energy Web • Jo Ann BAREFOOT, CEO, Alliance for Innovative Regulation • Bharath CHARI, Co-founder, XRP Ledger Foudation • Mark CACHIA, CEO, Scytale Ventures
16.10	**Panel Discussion 3 – *Can blockchain solutions scale? Tales from the industry*,** *moderated by Arno LAEVEN, SSI and Energy Lead, Dutch Blockchain Coalition* • Nik SCHARMANN, Project Director "Economy of Things", Bosch • Barbara HANNA, Delivery Manager IoT, Vodafone Business • Micha ROON, CTO, Energy Web
17.00	**End of event**

Speakers Biographies

Prof. Dr. Gilbert Fridgen, PayPal-FNR PEARL Chair in Digital Financial Services at the SnT, the Interdisciplinary Center for Security, Reliability and Trust at the University of Luxembourg.
He is head of the Financial Services and Interorganizational Digital Transformations Research Group (FINATRAX); he analyzes the transformative effects of digital technologies on individual organizations as well on the relationship between organizations. He thereby especially addresses potentially disruptive technologies like Blockchain/DLT, Artificial Intelligence, Internet-of-Things, or Quantum Computing. His research involves innovative business models, regulatory compliance (RegTech), IT strategy and (risk) management, IT capabilities and performance, as well as the design of innovative solutions. In his projects and partnerships, he collaborates with various industries, like financial services (FinTech), energy, mobility, manufacturing, consulting, as well as with public bodies (LegalTech). He regularly speaks at business-related conferences and gives interviews to media outlets. He served as an expert for multiple governmental bodies, such as the German Bundestag and altogether 6 German Federal Ministries as well as for the European Commission with its European Blockchain Partnership and European Blockchain Services Infrastructure (EBSI) and in the Academic Advisory Board of the International Association for Trusted Blockchain

Irene ADAMSKI, Co-chair WG Energy, INATBA
Self-Sovereign Identity, DLT in Energy and the global blockchain ecosystem - supporting innovation, collaboration and standardisation together with start-ups, industry actors, regulators and international associations.

Marco LOPRIENO, DG CLIMA, European Commission
Principal Administrator DG CLIMA @European Commission, Brussels. Responsible for developing blockchain projects and strategies to support EU Climate Policy development and implementation. 19 years climate policy working experience, out of which 16 years responsibility and technical experience in Monitoring, Reporting and Verification (MRV) of GHG emissions, first in the EU ETS (2005-12) and then as member of the International Carbon Markets team. Responsible for ETS technical cooperation projects in China, South Korea, Tunisia, covering Asia (PRC, ROK, Japan, Taiwan) . Developed and implemented MRV legislation in the Maritime sector (2013-17). Responsible for development cooperation projects in Central West Africa in DG DEVCO and for eco-labelling in DG Environment. 8 years working experience in the private sector (chemicals) at international and national level (Italy).

Alex de VRIES, Founder, Digiconomist
Well-rounded professional in FinTech and the FS sector. Global influencer, speaker and specialist in Bitcoin and blockchain. Public speaker at conferences such as Consensus and CEBIT. Insightful knowledge of AML/KYC procedures. Took control of setting up a data analytics function at the Dutch Central Bank. Investigated systematically and wrote papers on sustainability of Bitcoin mining.

Alexi ANANIA, Research Coordinator, Cambridge Centre of Alternative Finance
Having demonstrated a distinct skill set in cryptoeconomics and mechanism design, Alexi focuses on emerging technologies within the Distributed Ledgers (DLT) industry, paying particular attention to both internal and external structuring, as well as project stakeholder management. Alexi offers unique utilitarian education to startup companies and existing legacy companies seeking to incorporate DLT in their traditional business-models, as well as regional exploratory research required for issuing/managing security tokens in equity, real estate, debt or other alternative assets.

Alexi has authored papers for Bitcoin Improvement Proposals (BIPs) and their impact on privacy. He is a co-founder of a startup cryptocurrency exchange (BarterTrade.io) and is also currently a Blockchain Research Analyst at the Cambridge Centre for Alternative Finance (CCAF), an international interdisciplinary research institute of Cambridge University.

Marianna Belotti, Co-chair Governance WGz, INATBA

After having completed her studies on Quantitative Finance (Mathematical Engineering) in Politecnico di Milano, Marianna Belotti joined the Blockchain and Cryptoassets Programme of Caisse des Dépôts Group within the CIFRE program (industrial PhD) where she carries out research and development works on projects of strategic importance to the French institution. Marianna has several publications, related to Blockchain technology, exploring its potential use-cases and its adaptability and security issues. She is, now, in charge of the BI operations of the team and the animation of the Think Tank meeting of LaBChain (a consortium grouping the major actors in the French Fintech ecosystem). Marianna has also obtained the Business Foundation Certificate from INSEAD

Ioannis Vlachos, INTRASOFT International

He is a highly seasoned professional with more than 15 years of experience working with large corporations and educational institutes worldwide in the area of smart grids as a scientific expert, project manager, commissioning expert, and consultant. He has also worked closely with both academia and industry in more than 30 countries worldwide in projects that merge the worlds of energy and ICT. Vlachos has also advised ministries, national regulatory authorities, and utilities in the context of projects financed by international institutions. He has co-authored more than 40 scientific publications in international journals and conferences with more than 1,000 cross-references. He has been awarded with the “Ericsson Award of Excellence in Telecommunications” and in 2019 received the “Researcher of the Year” award in the area of blockchain technology for the energy sector.

Walter KOK, CEO, Energy Web

Walter is CEO of the Energy Web Foundation. He brings nearly three decades of experience leading customer solutions and operational teams in complex, global organizational environments, including in the fields of fintech, telecommunications and information technology (IT).

Prior to joining EWF originally as COO, Kok was COO of bank-wide operations at ING Bank, where he drove a series of transformation programs and built a new type of operating model better equipped to deal with the challenges of regulatory requirements and technological disruption. In addition to ING, Kok’s prior experience also includes senior board positions at Vodafone Global Enterprise, BT, NEC Corporation and several startups.

Joe Ann BAREFOOT, CEO, AIR

Jo Ann Barefoot is CEO & Cofounder of AIR - the Alliance for Innovative Regulation - and host of the global podcast show Barefoot Innovation. A noted advocate of "regulation innovation," Jo Ann is Senior Fellow Emerita at the Harvard Kennedy School Center for Business & Government. She has been Deputy Comptroller of the Currency, partner at KPMG, Co-Chair of Treliant Risk Advisors, and staff member at the U.S. Senate Banking Committee. She serves on the board of Oportun; on the fintech advisory committee of FINRA; on the Milken Institute U.S. FinTech Advisory Committee; and on the California Blockchain Working Group Advisory Board. Jo Ann previously chaired the boards of directors of the Financial Health Network and FinRegLab and served on the CFPB's Consumer Advisory Board. She currently serves on the boards of FinRegLab and the National Foundation for Credit Counseling. Jo Ann cofounded Hummingbird Regtech and, in 2020, was named to the Fintech All of Fame by CB Insights. AIR was honored in Fast Company's 2021 awards on World-Changing Ideas.

Bharath CHARI, Co-founder, XRP Ledger Foundation

Bharath is a marketing, media and technology professional with experience in a variety of sectors, including high tech consumer services, FMCG and advertising. He has proven expertise in introducing innovative or high value products and services to multiple markets (India, SE Asia, Middle East, Africa, Europe) including subscription-based offerings. His responsibilities have included strategy development, integration of production and distribution planning, technology roadmap, as well as developing media and marketing strategies, and the overall P&L of the business. He is also a founder-director of a venture in Estonia that operates in the areas of retail, technology and trade advisory services. He has a deep affinity for technology and is an active contributor to open source projects. Through the technology division Alloy Networks, he runs a validator on the XRP Ledger and also core infrastructure for the same.

He is board member for the XRP Ledger Foundation, whose mission is to further financial and social inclusion on a global scale.

Marc CACHIA, CEO Scytale Ventures

Starting his financial markets career on Wall Street in 1994, Mark went on to head the alternative investment group at Erste Group Bank in Vienna Austria. Mark has over 18 years of experience in institutional investing. Most recently, he served as Board Member and CEO of Infinity Capital Group, an investment company based in Bratislava. Mark is also an investor in Blockchain and smart-city tech.

Arno LAEVEN, SSI and Energy Lead, Dutch Blockchain Coalition

Active in blockchain and enterprise since 2015. Founder and lead of blockchain teams at Royal Dutch Philips and Royal Dutch Shell. Advisor to Bosch, KLM and executive role at Energy Web Foundation. Expert reviewer for European Commission Horizon 2020 on blockchain.

Barbara HANNA, Delivery Manager IoT Vodafone Business
Technologist (CV/ML, Sw. Eng) with 20 years of experience developing and managing pioneering technologies and teams in industry, start-up and academic settings, and translating complex technological concepts into practical, user experience minded systems and products across a number of technologies, industries and applications. She is particularly passionate about developing technologies and growing businesses that educate, empower and/or connect individuals.

Barbara is co-author and author on peer reviewed publications and US patents. She holds a BEng. and MEng. from the University of Cambridge UK, and a Ph.D. in Computer Vision from the University of Surrey, UK.

Nik SCHARMANN, Project Director Bosch
Nik Scharmann has been leading Bosch's research activities in the field of the Economy of Things since 2017. Before that, he was a researcher in the energy technology field at Bosch Rexroth, where he began his career as a trainee in 2002.

Mich ROON, CTO Energy Web
By working closely with the management and end-users of many international companies and organizations, Micha acquired a unique combination of business understanding and in-depth technical knowledge. He brings a wealth of experience in data modeling, blockchain development, project management, and business analysis and requirements engineering. Prior to EW, Micha was CTO at Share & Charge Foundation. In addition to Share & Charge, Micha's previous experience also includes the position of lead blockchain architect at SweetBridge, development team lead at PostFinance, and technical project management at Swisscom.