7 Blockchain Technology in the Energy Industry
A Review on Policies and Regulations

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7.1 INTRODUCTION: BACKGROUND AND DRIVING FORCES

In recent times, energy industries all over the world have become increasingly concerned with environmental efficiency, reliability, transparency, accountability, social responsibility, social inclusiveness, and so on and so forth. These points are now more applicable than ever since COVID-19 wreaked havoc in the socio-political world order. The world has been forced to contribute to social and environmental causes and promote sustainability. Besides, many developing countries are carving

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new strategies and policies in a bid to attract new investments, including small and medium-sized enterprise (SME) investors (Gómez-Bolaños et al., 2020).

Nevertheless, missing opportunities to attract new or foreign investors are prevailing in the energy sector of developing countries due to the challenges stemming from corruption, obscurity, technological uncertainty and political instability (Baloch et al., 2020). Furthermore, the lack of transparency in the power industry associated with demand and supply and the security of energy supply is a pressing matter for many countries, including Brazil, India, Indonesia, Bangladesh, Pakistan and many nations in Africa (Debnath & Mourshed, 2018). The conventional trends and the regulations between the government and stakeholders in the above-mentioned countries have failed to safeguard the interests of the investors. As such, considerable economic hardship could be at stake.

An economical and stable electricity supply is often central to the economic development of a nation. The advent of new disruptive technologies offers a critical environment; if employed properly, it can handle the major perils lingering in the energy sector. New innovations not only change the system technically but also change the strategies of economic development by safeguarding the environment and protecting the expectations of the stakeholders (Debnath & Mourshed, 2018).

Blockchain, as a disruptive technology, poses various opportunities and challenges to traditional business standards, including the energy industry (Oh et al., 2017). Hence, this chapter strives to delineate the opportunities and challenges of blockchain technology in the energy industry to date and analyses existing examples and cases where blockchain is utilized in the energy sector. Then, it offers an overview of the potential opportunities as well as the challenges relevant to blockchain in the energy sector. This chapter additionally sheds light on potential opportunities and challenges faced by the policy-enforcing authorities concerning the application of blockchain technology in the energy industry. The research employs the qualitative method of data collection and primarily focuses on an exploratory literature review. The analysis part is focused on broad literature sources, mainly peer-reviewed publications.

Technological development in a specific industry requires both regulatory and policy reforms. In line with that, this chapter examines the internationally functioning models of blockchain technology in the energy industry, such as innovations for trade (using "smart contracts") and investment and promoting peer-to-peer (P2P) energy production. The analysis of the models has been helpful to recommend the utilization of blockchain technology in the energy industry. This eventually paves the way toward appropriate governance frameworks to ensure decentralized, transparent and sustainable energy development. The study has two main objectives. A key contribution of this chapter is that we delve into case study-themed analysis of innovations being embraced in the energy sector: For instance, smart contracts to facilitate smoother trades. We also investigate the promotion of P2P-based production of energy. Lastly, we analyse existing policy and regulatory frameworks in place that are supposed to help the energy industry absorb the incoming innovative disruptions.

7.2 BLOCKCHAIN TECHNOLOGY IN ENERGY INDUSTRY: INTERNATIONAL USAGE AND PRACTICES

Due to the speculative bubbles in the cryptocurrency markets, modern citizens consider blockchain synonymous with applications in the finance, banking and fintech industries. In other words, the payment and mode of exchange applications of blockchain grab the largest number of headlines (Upadhyay, 2019). Nonetheless, with cryptocurrencies exhibiting enough independence in their pricing and market dynamics behaviour, the controversy over whether they are an independent asset class is nearing an end (Sifat, 2021). As such, the novelty aspect of cryptocurrencies is effectively fading. This makes possible greater propagation of news to the public about the myriad applications and extensions of blockchain-based initiatives. The nature of blockchain technology has changed the fintech industries because of its high performance and the fast and stable nature of transactions. Besides, blockchain is claimed to have the ability to enable financial trades, breaking down national currency frontiers (Chakravarty et al., 2020). Additionally, blockchain is said to reduce the burden of audits on every financial ledger (Queiroz et al., 2019).

Nevertheless, blockchain has its implications beyond digital currencies. In fact, there are various uses of this technology, ranging from land and property registration to property possession and trade protection (George et al., 2019). It can also be used, as we know, for international cash payment, fund transfer and recording intellectual property rights and copyrights for different industries (Chang et al., 2019). As for payment systems, blockchain technology is the smartest application, with greater accessibility, a more agile platform, less proneness to errors, and smoother transfers than those of the other existing payment and settlement processes. In addition to the fintech industry, blockchain has a potent future in the energy industry. For the energy market, however, blockchain can be a very expensive data storage tool (Hou et al., 2019). It is indeed unfortunate that barring the financial industry, blockchain technology has received sparse attention – particularly in the energy sector (Hald & Kinra, 2019).

Lack of understanding of this new technology has posed challenges for regulatory bodies, and many lawmakers and enforcers do not show adequate comprehension of its scope and implications (Rennock et al., 2018). Therefore, the energy market (for good reasons a heavily regulated market) will not be a suitable choice for the proliferation of decentralized blockchain technologies. Given this, it is still true that in addition to enabling money exchange, blockchain technology will be able to accommodate complex tasks such as tracking activity, property recordkeeping and exchanges, transfers of environmental and social goods, etc. As of the first quarter of 2021, another innovation of blockchain-enabled technology is gaining momentum – nonfungible tokens. These tokens are exhibiting the limitless power of blockchain technology in not only storing memory but also keeping accurate records and historical snapshots. There have already been some implementations of blockchain in the energy industry. This part of our discussion focuses on the possibilities that blockchain can bring to the energy industry.

7.2.1 Energy Trading on a P2P Basis

A recent paper by the German Energy Agency (DENA) reveals that the executives of the German energy sector opine that blockchain technology's blueprint holds promise for creating an effective, accessible and – crucially – sustainable infrastructure of power generation and distribution (Mika & Goudz, 2020). The bulk of industry practitioners also believe that eventual expansion of this sector is highly likely – as per the latest DENA survey (Burger et al., 2016). The existing views of market leaders today may be heavily influenced by internet buzz and new prospects around the consultancy sector. Due to the still embryonic nature of this technology's prospects, there are no adverse precedents of blockchain technology creating accidents or making unsavoury headlines to dissuade analysts' attitude toward a technological transition to a more sustainable energy infrastructure.

It appears that the uncertainty surrounding the way blockchain technology will eventually transform the industry is not large enough to discourage quick adoption. Indeed, several consortiums have already been formed to bring together multiple industries to further this technology's reach and accelerate its adoption. The Energy Web Foundation is expected to partner with players of the blockchain working groups in the energy sector around the world to create a flexible, open-source platform targeted directly toward the energy industry demands and design it to be energy efficient (Burger et al., 2016). Singularity (a well-known start-up in the energy industry) is in collaboration with the Rocky Mountain Institute (an American energy company) to create a partnership for the energy industry with the vision of making blockchain more productive to encourage more efficient operations in the energy sector (Bürer et al., 2019). The new partnership seeks to pursue R&D in blockchain and energy to help utilities or investors, technology creators, consumers and green energy firms realize how current market structures may be assisted, undermined or transformed.

Bloomberg New Energy Finance (BNEF) has published one case of a company using blockchain solutions to attract new consumers (McCrone et al., 2019). BNEF considered that Tokyo Electric Power Co. would like to regain customers' trust and confidence by restoring a transparent information structure in the domestic market (McCrone et al., 2019). Japan's largest power provider has developed a company called Trende, which attempted to enter solar energy production and enable P2P power purchases of solar technologies via blockchain (Martin, 2018).

Smaller companies, start-ups and pioneering firms are aggressively experimenting with P2P trading. This extends to both utility services and energy-based frameworks. Such trading through blockchain can bring possible technological changes. These changes can eventually generate more profit for some customers (Martin, 2018). Consequently, blockchain may shape the prospective future of P2P power trading, since the energy start-ups are looking forward to offering competitive deals through innovative technologies. Nevertheless, it is yet to be understood how such peer-to-peer transactions can be coordinated on a scalable level; therefore, maintaining improvements in the infrastructure that facilitates such power trading is quintessential. Several countries are already experimenting with P2P on a limited scale, adopting a pilot approach.

7.2.2 Managing Energy Supply and Demand in Real Time

Electricity markets are constantly forced to balance supply and demand. Such a balance is a challenge for both renewable and fossil fuel-based energy generation. In the transition process from fossil fuels to renewable sources, many countries are in desperate need of new flexible systems to accurately forecast the power demand and match the supply accordingly to the system. Hence, a transparent data structure (backed by blockchain technology) is also essential to evaluate energy sources and prepare them for quick adaptation in times of scarcity.

Blockchain (theoretically) is a technology that can offer stable, real-time data transmission and allow effective monitoring and maintenance of electricity-industry infrastructures. The technology can also provide quicker response times (again, in theory) in an emergency (Siemon et al., 2020). Data is expected to be protected and accessed by each stakeholder. Blockchain is anticipated to add a security and collaboration layer to the existing digital pilots by allowing quick, reliable data collection and connectivity between equipment vendors, infrastructure maintenance, and emergency response teams. In order to serve that purpose, Tennet TSO GmbH (Germany) is now partnering with battery manufacturers IBM and Sonnen GmbH to establish a non-physical line of transmission utilizing blockchain-based technology to use the surplus electricity extracted from wind turbines and store the power using batteries. The storage power is then distributed through electric grid lines in the southern part of the country (Höhne & Tiberius, 2020). This decreases the power and infrastructure cost associated with installing new lines (Höhne & Tiberius, 2020). The UK-based corporation Electron is also planning a new breakthrough in terms of the supply chain model by utilizing blockchain technology (Goranovic et al., 2017). The company is also using blockchain to build (via versatility marketplace) a framework to maintain the power demand and supply. This phenomenon is dubbed Energy eBay because of its tremendous prospects and role in stimulating widespread industry participation (Goranovic et al., 2017).

Developing countries, still undergoing the ultimate hurdle of ensuring sufficient energy supply, can implement blockchain-powered applications to make the demand forecasting strong and accurate via real-time data analytics from the system. Such exposure of information can help the regulators to effectively manage the supply of electricity following its economic mandates. Real-time demand signals emitting from a blockchain-based ledger include the ability to transact between all the assets demanded and supplied, therefore helping to make effective decisions (Dong et al., 2018).

7.2.3 Promoting Investments in Energy Industries

According to Crunchbase (a multinational start-up database), at this moment, 140 companies are rapidly heading toward the blockchain-empowered energy sector (Andoni et al., 2019). Start-ups appear to be leading advancement in transforming the business models in the electricity industry, riding on the back of blockchain-based applications (Deign, 2017). Blockchain technology offers transparency to investors.

Governments are aiming to form strategic alliances with the energy start-ups with a view to employing the blockchain technology for quicker responses and incorporating trust in the system to break the conventional model of the slow licensing process (Andoni et al., 2019).

Start-ups can act as a potent player, transforming the energy market through blockchain-enabled technologies. Nonetheless, to be a successful disruptive actor for the energy revolution in reality, there is a crying need for solemn commitments and support from governments. Risks and incentives to achieve priorities such as climate change and energy transformation targets must be carefully considered when working with the appropriate grid infrastructure. Blockchain technology can trace the energy investments in different electricity sources and promote sustainable energy solutions.

US-based company TransActive Grid, Power Ledger and Singularity from Australia, Ideo CoLab, etc. are some of the start-ups in the energy industries that are efficiently utilizing blockchain technology (Wang et al., 2017). These companies have demonstrated that specific usage of blockchain technology increases the efficiency in supply analyses of the energy industry, helps in pricing and project profits, assists in electricity sharing, provides options for automated power plants, and performs microgrid management (Agency, 2016). In the meantime, such innovations can also be exploited to trade renewable energy certificates (RECs), which are typically given to the producers of solar energy based on the anticipated production demands rather than actual figures. Several innovative ventures are already engaged in designing grids and systems to facilitate power production in order to be able to get these certificates. One such firm, Volt Markets, supplies energy and monitors a trade network built atop smart contracts underpinned by Ethereum's technology (Henderson et al., 2018).

7.2.4 Increasing Energy Access in Developing Countries

In the energy sector, blockchain can also retain its original purpose and be used as the cryptocurrency for monetary transactions; in fact, some companies have already begun this campaign: For instance, SolarCoin, Bankymoon and BlockCharge, to name a few (Kumar, 2018). In terms of blockchain usage, start-ups are still involved, while applications are catching up. Others would go for joint ventures and cooperations as a viable option. Hence, the value blockchain proposes would be the removal of brokers as intermediaries between parties.

In principle, a complete decentralization of the energy sector through blockchain implementation may be accomplished if financial transactions are removed from central control. These advances may further allow room for inventions that over time would increase access to electricity in developing countries. Take smart prepaid meters as an example: A technology that only releases power to residential consumers after they have updated their accounts and moved money to their energy supplier (Chitchyan & Murkin, 2018).

This program could be advantageous for high-inflation countries like the BRICS economies or South Asian nations. Conceptualizations of the technology came from

a South African enterprise – Bankymoon – which leverages bitcoin's network to enable remote payment systems (Dogo et al., 2019). For poor economies that suffer from a lack of economic resources, such innovations bode well. As for the altruists who want to donate to help schools carry on their activities, they can bypass the traditional restrictions and dive right into crypto-based systems to contribute to the school's smart meter. Consequently, the schools will receive power credit and instantaneously achieve energy self-sufficiency without unnecessary hassles from intermediaries (Henderson et al., 2018).

Blockchain can also enable crowdfunding in the energy sector and increase energy access in developing countries (Arnold et al., 2019). Numerous solar panel schemes are still left unfunded in many parts of Africa, most of which are worth less than 1 million USD (Brilliantova & Thurner, 2019). Crowd-financing could fill in this funding gap; people around the world would be able to buy the photovoltaic cells that will make up the solar panels on African homes (Higgins, 2016). The solar panels are only installed when enough solar cells are pre-purchased. Throughout the crowd-sale duration (a certain finite amount of days), the total an investor wants to pay is assigned to the number of solar cells he can get for it (because of bitcoin's volatility) (Brilliantova & Thurner, 2019). These cells provide African households with electricity, and households, in turn, pay investors a rental income in bitcoin for several years. The blockchain platform is used in this case to fund access to electricity.

7.2.5 Regulatory Reporting and Compliance

Regulators constantly expect energy and resource firms to have large volumes of data that can be evaluated to identify non-compliance with legal and regulatory requirements (Diestelmeier, 2017). Collecting and analyzing the necessary data is a big challenge for the latest technology and applications. There is also a substantial danger of the data falling into the wrong hands and being misused, exposing confidential business information and placing a company at a strategic disadvantage.

Blockchain could theoretically solve many of these problems, facilitating accountability and encouraging regulators to access secure, transparent data safely at source and encouraging businesses to keep tight control over what information is accessible and who can access it (Diestelmeier, 2017). A significant side advantage of having such a forum to exchange knowledge with regulators is that it will establish an industry-standard data format, which is impossible at present (Bürer et al., 2019).

Energy companies are particularly worried about trade secrets. Private blockchain networks offer pre-approved parties' authorization for data and limited consortium entry. Private and cooperative blockchains offer an intermediate alternative before the required privacy features of business demand can be introduced by the public blockchains (Bürer et al., 2019). Blockchain's core points of focus on the electricity market are cost reduction, sustainable development and increased accountability without sacrificing privacy, which can bring a paradigm shift to the whole energy sector of a developing country within a short span.

7.3 PROSPECTS OF BLOCKCHAIN TECHNOLOGY IN ENERGY INDUSTRY

Blockchain technologies are deemed to be one of the most forthcoming pathways to expedite the entrance of various energy sources. With plausible reasons, structuring a blockchain-based communication system certainly offers appealing characteristics. Blockchain can adequately respond to numerous obstructions found in the energy sector of developing countries. Furthermore, it can cater to the corresponding requirements of the local trade in electricity production and consumption from a particular vantage point to provide the replenish the shortage amount to the power grid.

A wide range of business and operations relating to the energy industry may be regulated with blockchain technology (Edeland & Mörk, 2018). Smart metering and smart contracts generated from blockchain technology can usher in a new era of automated billing for customers and distributed generators. Pay-as-you-go platforms can benefit both consumers and utility companies. The potential of energy micropayments can only be exploited with the help of blockchain technology (Burger et al., 2016).

Energy sales practices will change in most countries accordingly, depending on the environmental aspects, individual preferences and the customer's profile (Burger et al., 2016). Blockchains can classify market energy trends with artificial intelligence (AI) techniques like machine learning (ML) (Singh et al., 2020). Distributed trading platforms allowed by blockchain could dislocate business operations such as risk management, demand control and commodity trading (Andoni et al., 2019).

Blockchains can also expand the power of autonomous microgrid and energy systems (Burger et al., 2016). Blockchains can theoretically be used to provide smart grid solutions with the combined usage of smart meters, automated sensors, network security equipment, energy storage and control systems, and smart home energy controllers and building control systems (Khaqqi et al., 2018). These intelligent systems can be used with enhanced potentiality through the application of blockchain technology-enabled smart grids. Besides, blockchains can assist with network security, flexibility or asset management of decentralized networks and can offer integrated flexible trading networks to leverage scalable infrastructure (Pan et al., 2020). Smart contracts will also theoretically ease energy trading and enhance energy mobility, potentially lowering energy tariffs. Immutable databases and consistent procedures can dramatically improve auditing and compliance with regulations (Thomas et al., 2019).

Blockchain in the energy industry can attract prospective investments. Tyro firms or inexperienced start-ups can enjoy low barriers of entry into this sector via P2P energy trading models. For a developing economy, blockchain certainly has the answers to numerous challenges regarding the decentralized energy production scenario (Giotitsas et al., 2015). It can further aid the policymakers of the country to discern the energy demand and deviations in real time through grid simulations. For policymakers, blockchain is also helpful in demand planning and all the accompanying considerations through the implementation of this technology (Kiviat, 2015). As a result, the costs of electricity would be open to all parties concerned. This includes the grid responsible for distributing power and utility companies.

Another important benefit of implementing blockchain in the energy industry is that all the electricity that the network delivers can be allocated in small units to individual customers. This allows the precise calculation of all electricity generated and consumed. A much-improved database would help to finalize network operations better at distribution and transmission levels. Figures 7.1 and 7.2 present the current market roles and how the system would change if blockchain technology were used.

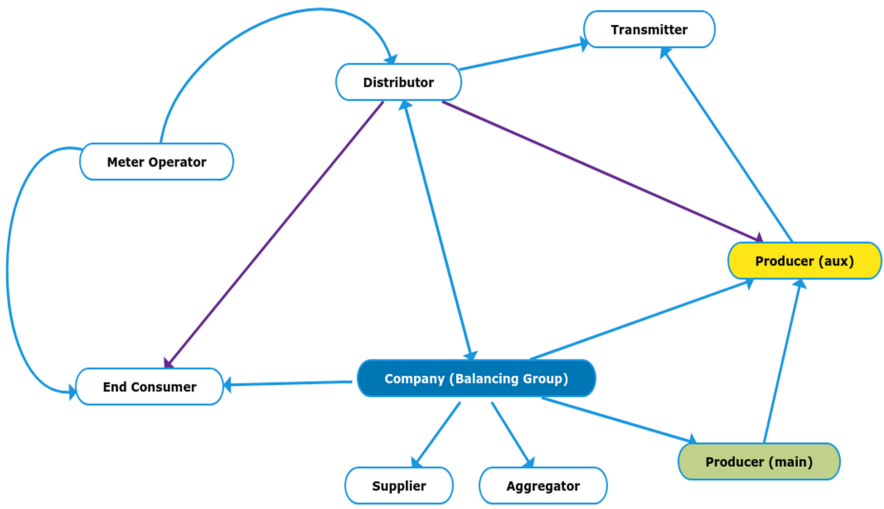

FIGURE 7.1 Contemporary energy market.

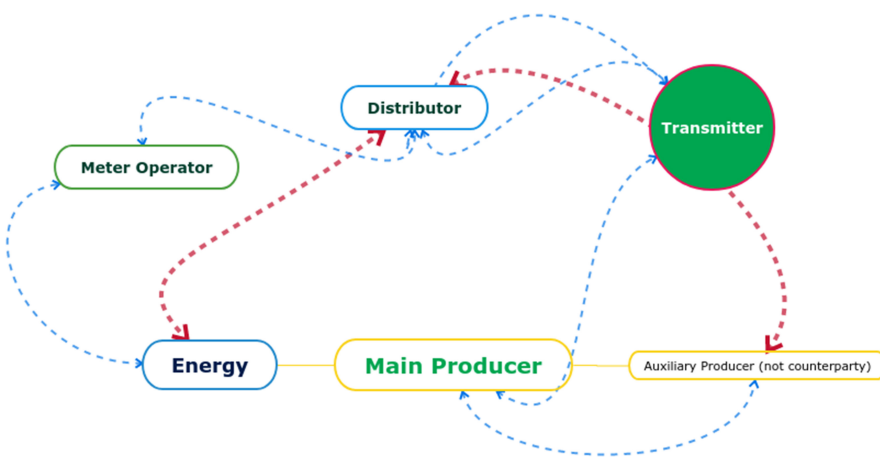

FIGURE 7.2 Energy market structure using blockchain.

Blockchain technology enables direct contracts between energy consumers and power producers. Therefore, all consumers must comply with energy laws, especially the laws relating to energy safety and risk management. The function of meter operators will change; they will no longer need to gather and monitor data themselves, since all information on use and transaction is immediately and precisely shared using the blockchain technology through smart contracts.

To deliver electricity directly to consumers from a power supplier and complete a financial exchange between the parties on blockchain technology, both the parties must integrate within the system. Since the energy consumer (see Figures 7.1 and 7.2) will continue to use power from the network, the consumer will eventually be the meter operator. The practical challenge begins as the question remains whether the consumer can effectively understand and adhere to the technicalities relating to meter reading (PricewaterhouseCoopers, 2016). Blockchains are still to be implemented in energy market communication systems. A blockchain model in the energy industry can create a substantial financial and organizational obstacle. One significant barrier stopping the implementation of transaction models based on blockchain is that they must conform to existing regulatory requirements (Diestelmeier, 2019). Any of the advantages that a decentralized P2P relationship structure would offer are then missed.

A blockchain roll-out will have a significant effect on energy market competitiveness. There is a possibility that small or local firms will face fewer obstacles, while big investors will be financially affected. Conversely, many experts believe there is a solution to this (Löbbe & Hackbarth, 2017). Setting up private blockchains with lucrative offers for consumers will allow them to remain in the market (Löbbe & Hackbarth, 2017). In such a case, small vendors will fail to include them in the transaction model of the energy market. The existing insecurity regarding legal and regulatory approval is another hurdle for blockchain implementation in the energy industry. Compared with the anticipated blockchain-based energy model, the existing regulatory structures are focused on a simple distribution of corporate and legal obligations.

7.4 LEGAL AND REGULATORY CHALLENGES

With every dramatic transition to new technologies, blockchain poses a range of legal concerns. Legal concerns vary from private to public international law and from financial to energy laws and regulations, based on the nature and scope of blockchain applications. Some of the legal concerns of blockchain relating to energy industries are highlighted here.

7.4.1 Applicable Law

The topic relating to applicable law is the first issue posed in blockchain. In blockchain, jurisdiction is important since the parties of each transaction will be in separate countries. Hence, determining the applicable law will be challenging. For each transnational transaction in blockchain, all the parties to the smart contract will feel

the necessity to understand applicable/governing law. This problem only does not arise in situations where the parties to the agreement reside within the EU, as the legislation applicable to contractual obligations remains the same: The "Regulation of the European Parliament and of the Council on the law applicable to contractual obligations (Rome I58)" (Giancaspro, 2017). But what happens if the contracting parties are not in the EU?

The matter should then be dealt with under either private international law or the applicable law mentioned in the contract (Governatori et al., 2018). A possible solution to this may be providing a range of alternative options to choose the applicable law in a smart contract by clicking on the preferred country or region. In the case of imposing blockchain applications in the energy industry, selecting a proper governing law for each transaction may lead to complex legal and regulatory situations, which the tech giants and the government should consider with a more profound and holistic approach.

7.4.2 Identity within a Blockchain

Most of the energy-related blockchain applications so far are held in public blockchains. All transactions in public blockchains are easily accessible. Nevertheless, transactions in public blockchains do not indicate that the identity of the parties is always understandable. For example, the parties in a bitcoin transaction can participate anonymously. This can be an added advantage for cryptocurrency situations; nevertheless, it contributes to difficulties for energy industries, both politically and philosophically (Diestelmeier, 2019). Unidentifiability will lead to a situation where the stakeholders cannot identify the real problem or hold any authority responsible for a wrong, which stands against the core philosophy of introducing blockchain into the energy industry.

In this case, money laundering on Emission Trading System (ETS) markets, or market theft due to confidentiality, will remain as a persisting challenge in the energy market even though blockchain applications are introduced. Therefore, the existing situation of market exploitation and uneven competition by large energy vendors and suppliers cannot be easily changed through blockchain applications (Maksimenko, 2019). This will affect the integrity of the relevant traditional economy unless blockchain applications that can identify the parties in energy transactions are implemented. Therefore, a range of regulatory reforms have been developed relating to blockchain applications, especially in the financial sector. While there are expert arguments on the blockchain recognition/identification of electronic profiles (Caytas, 2017), such access to identity remains unanswered due to technical and regulatory barriers.

7.4.3 Liability and Responsibility

The perfect blockchain paradigm allows for a mechanism that totally operates without a responsible central authority (Radziwill, 2018). This means that a legal personality is not defined in blockchain applications (Kshetri, 2017). If any damages arise,

the existing liability laws and regimes are not sufficient to deal with the compensation (Corrales Compagnucci et al., 2020). This constitutes a series of legal dilemmas. Hence, specific liability laws relating to blockchain in energy industries are needed to guarantee the legal responsibilities of the parties involved. Specific laws are needed to administer the liability principles in payment defaults, technological breakdowns, deliberate non-performance, etc. As the energy industry typically entails using vital infrastructure, the stakeholders need an emergency plan to specify the protocols in case of a disaster.

7.4.4 Personal Data

One of the basic features of blockchain contradicts the personal data laws. Most of the laws relating to data protection state that personal data must be deleted after they have served their purpose. Industry experts and the scholarly community have long pointed out that blockchain technology engenders privacy concerns. Prominent among them is the contravention of the EU's data protection regulation, popularly called GPDR (Feng et al., 2019). The original intent of this technology was to facilitate P2P transactions without a centralized data verifier. Therefore, no single party is supposed to hold the power to hold a particular network hostage. For this reason, the entire system should be permissionless so that everyone in this system can equally access the data within. In the case of sensitive data in the healthcare industry, blockchain certainly breaches several privacy principles, such as "Rights of Data Subjects", "Security Principle", "Retention Principle" and "Right to be Forgotten" (Fabiano, 2018).

7.4.5 Challenges with the Financial Market Regulation

As finance transactions move from energy providers or banks to a P2P system, the question arises of who is accountable for securing each financial transaction's settlement. Such a duty of care could not be levied on energy users and providers alone. Instead, an individual body or a network operator should be formed to conform to the requirements of financial services in compliance with the banking laws and regulations.

7.5 POLICY RECOMMENDATIONS

Policymakers need to collaborate with the industry and ensure regulatory enforcement to benefit from blockchain technologies. In some instances, policymakers cannot implement comprehensive, prescriptive and detailed guidelines, as the technology itself is in its embryo stage. Policymakers must promote technology through flexible laws to cover a large spectrum of technical applications. In all cases, regulators should collaborate with stakeholders to ensure that the implemented laws/rules and regulations are well thought out for the industry.

Among the proposals put forward as a remedy, regulatory sandboxes stand out as a highly promising solution pertaining to distributed ledger technology (Ahl et al., 2020). These allow an opportunity for program testing in isolated and highly

regulated environments with real people and bona fide consumers. The entire process is also free from threats of regulatory intervention or retaliation. Furthermore, policymakers may have an opportunity to understand better the underlying technology in action and work closely with industry stakeholders to further refine and fine-tune the enforcement procedure. The result here will be the formulation of a regulatory framework that encourages and nurtures innovation without compromising security, privacy, accountability and forward-thinking solutions (Yeoh, 2017).

One challenge of regulatory sandboxes is to ensure that commercial energy sectors are appealing to them. Sandboxes should be promoting innovation and enabling energy start-ups to expand rather than merely offering legal value. The proliferation of decentralized systems affords regulators discretionary powers that can be misused or misapplied. For instance, participants may inadvertently fall into liability of compliance breach traps. Delicate handling of these matters is complicated by a lack of precedents in the legal materials. To further illustrate this point, let us consider privacy issues in sensitive systems. A few years back, the French government adopted a position that only participants actively injecting data into a system can be treated as bona fide data miners. This discounts the roles of minders or nodes who play a key role in transaction verification. Whether such positions will truly safeguard public interest in trustless systems is a matter of speculation. Whether or how transparency and accountability will be ensured for privacy and personal data spaces is another major concern.

The governance of any blockchain system is a critical issue, which is often overlooked. How a blockchain is governed defines its success and adoption in many ways. Interestingly, different aspects of a blockchain governance are analogous to how an organization or a consortium of organizations distributes responsibilities among themselves. Each organization/industry must understand this before they decide to adopt blockchain for their solutions. This calls for a new governance model, which itself might be challenging.

A regulatory framework surrounding any novel technology instils confidence among the adopters. On the contrary, the lack of any such framework creates uncertainties. Therefore, a blockchain-friendly regulatory framework can be an effective tool to overcome many challenges within an industry. It is evident that law and enforcement would work as a significant determinant to either open blockchains in the energy market or close them for good. The fast development of proactive regulation remains a challenge to the regulators. Devising this environment would ensure consumer protection and guarantee a secure and reliable supply of electricity. An absence of law or regulation regarding blockchain just might make investors sceptical about funding. Before investing in new technologies, it is common for the energy industry to be patient and wait for a long time for technology to catch up; the same goes for the emergence of policies too.

7.6 CONCLUSION

Recent policy actions concerning blockchain technologies are mostly concentrated into digital currencies and financial applications. Nevertheless, breaking the

boundaries of fintech, blockchain has so much to promise in the energy industry. Though the digital currency is illegal in many countries, the uses of blockchain technology are completely legal. It is imperative to use the potential of every new technology to achieve maximal growth and welfare for all countries. Blockchain has the power to unite various fragmented systems in order to generate insights and assess the value of care properly. In the long haul, a nationwide blockchain network to maintain energy records may enhance efficiency and bolster better investments. However, blockchain technology has not reached maturity, nor is it a silver bullet or an instant solution. Several organizational, technical and behavioural economic challenges need to be surmounted before adopting blockchain in the energy sector. Therefore, though this technology has tremendous potential, it is very important to note that such a technology should be dealt with cautiously and with sincerity.

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