

# Blockchain in Oil and Gas Industry

<sup>1</sup>Matthew N. O. Sadiku, <sup>2</sup>Philip O. Adebo and <sup>3</sup>Janet O. Sadiku,  
<sup>1,2</sup>Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA  
<sup>3</sup>Juliana King University, Houston, TX, USA

**Abstract:** Blockchain is a shared, distributed ledger which is to assist in recording the transaction and in trailing assets in a business network. Technology is already transforming industries and business processes, leading to completely new experiences and groundbreaking results, in terms of transparency, disruption, and innovation. It is increasingly becoming too compelling a technology that cannot be ignored for the oil & gas industry. It is emerging as a technology that demands attention within the oil and gas sector. It promises potential cost reductions and enhanced process efficiencies. It can aid contract execution in transactions where the level of counterparty trust is low or where transaction value or complexity is high. It assists in securing and simplifying oil and gas trading, shipment tracking, inventory control, documentation, and billing and payments. In this paper, we explore the potential opportunities and applications of blockchain technology in managing the exploration, production, and supply chain and logistics operations in the oil and gas industry.

**Keywords:** Blockchain Technology, Oil And Gas Industry, Petroleum Industry

## I. INTRODUCTION

Important advances in technology rarely come with a full embrace at the start. Ground-breaking ideas can yield as many doubters as disciples. It takes time, experience, growth, and eventual acceptance to turn an idea into reality. Digital technologies are aimed at transforming the oil and gas supply chain services, reshaping industry competition and ensuring the safety of workers. Emerging technologies such as artificial intelligence, Internet of things (IoT), cloud computing, and blockchain can play a vital role in boosting the operational efficiency of the oil and gas industry.

For many businesses, blockchain is the road to transformation. The role of this technology in the oil and gas industry has evolved through various stages. The initial focus was on supply chain management and reducing paperwork. Subsequently, smart contracts were introduced to streamline transactions, and blockchain's cryptographic security features became crucial for data management and integrity. Leveraging blockchain's distributed ledger capabilities can reduce the amount of time spent reconciling price and volume differences among trade participants by making the same data available to all parties at the same time. Recently, modern technologies have aided business titans in deciding to use digital currency rather than conventional trade to avoid fraud. Blockchain enables the existence of Bitcoin and many other cryptocurrencies. A cryptocurrency refers to a digital asset that works as a medium of exchange between various business organizations. Figure 1 shows the symbol of blockchain [1].

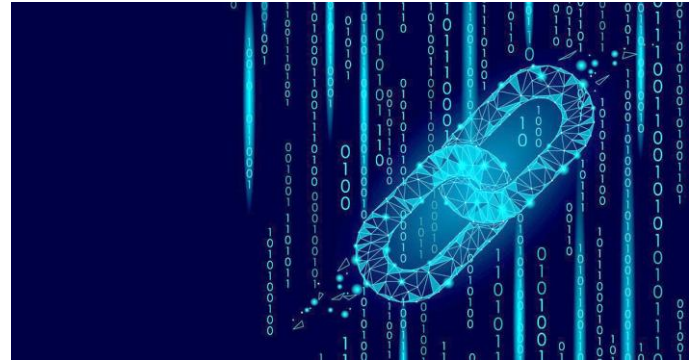


Figure 1 The symbol of blockchain [1].

The oil and gas industry encompasses thousands of companies spread across the globe. Both Chevron and ExxonMobil, two of the world's largest oil and gas companies, have shown interest in blockchain technology and its potential uses. In 2019, seven global firms in oil and gas companies formed the Global Oil and Gas Consortium. It is the first initiative of this kind. The recently announced consortium marks a groundbreaking milestone in the United States oil and gas industry. Chevron and ExxonMobil stand among the founding members [2].

## II. WHAT IS BLOCKCHAIN?

Blockchain, a type of distributed digital ledger technology (DLT), is a relatively new and exciting way of recording transactions in the digital age. It is a decentralized and distributed digital ledger technology that securely records and verifies transactions across multiple computers or nodes in a network. Basically, it is a chain of blocks in which each block contains a list of transactions. The blockchain technology was created as the foundational basis for Bitcoin – a digital currency in which secure peer-to-peer transactions occur over the Internet. It is expected that the spending on blockchain solutions worldwide would grow from 4.5 billion USD (2020) to an estimated value of 19 billion USD by 2024 [3].

Originally developed as the accounting method for the virtual currency Bitcoin, Blockchains are appearing in a variety of commercial applications today. Blockchain technology is a type of distributed digital ledger that uses encryption to make entries permanent and tamper-proof and can be programmed to record financial transactions. It is used for secure transfer of money, assets, and information via a computer network such as the Internet without requiring a third-party intermediary. It is now being adopted across financial and non-financial sectors. As a catalyst for change, the Blockchain technology is going to change the business world and financial matters in major ways.

The first Blockchain was conceived in 2008 by an anonymous person or group known as Satoshi Nakamoto, who published a white paper introducing the concept of a peer-to-peer electronic cash system he called Bitcoin [4,5]. Bitcoin and

Ethereum are the first two mainstream Blockchains. Other modern Blockchains include Namecoin, Peercoin, Ether, and Litecoin. Figure 2 shows different components of Blockchain [6].

with Bitcoin due to their common genesis, it has broader applications. Cryptocurrency will increasingly become a factor in family law issues as well.

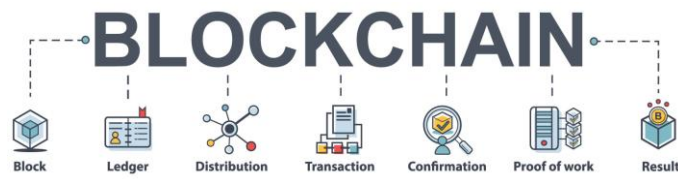


Figure 2 Different components of Blockchain [6].



Figure 4 Bitcoin [8].

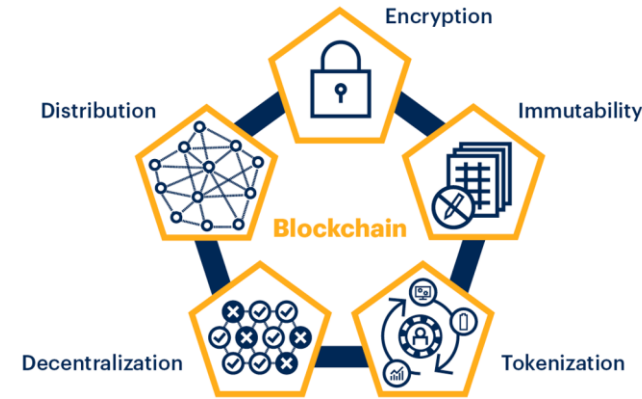


Figure 3 Five key elements of Blockchain [7].

Blockchain combines existing technologies such as distributed digital ledgers, encryption, immutable records management, asset tokenization and decentralized governance to capture and record information that participants in a network need to interact and transact. As illustrated in Figure 3, a complete blockchain incorporates all the following five elements [7]:

### III. BLOCK CHAIN IN OIL AND GAS

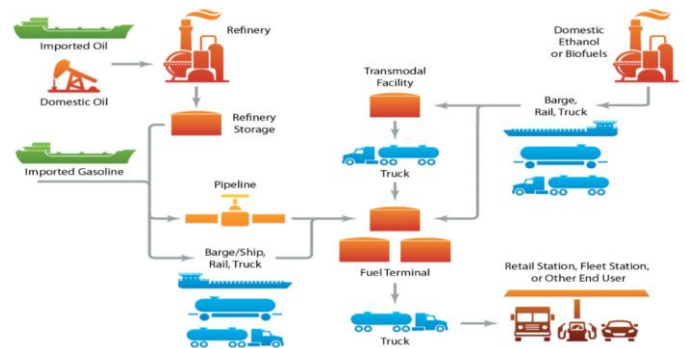


Figure 5 The complexity of the O&G industry [9].

The trading of oil and gas products such as gasoline and diesel is a highly standardized and quality-sensitive process that requires high security, privacy, and fast data processing. Oil & gas is a highly complex industry, sitting on the business of millions of barrels of oil and cubic meters of gas being bought and sold on international markets every day. The complex nature of the oil & gas industry involves multiple stakeholders and partners throughout the value chain. The complexity of the industry is depicted in Figure 5 [9]. The O&G industry does over \$1.7 trillion dollars in business every year. A research study has estimated that the adoptability of blockchain into the oil and gas industry can reduce the transaction execution time by 30%. Based on the type of service, oil and gas businesses are classified into upstream, downstream, and midstream categories [10,11]:

- **Distribution:** Digital assets are distributed, not copied or transferred. A protocol establishes a set of rules in the form of distributed mathematical computations that ensures the integrity of the data exchanged among a large number of computing devices without going through a trusted third party. A centralized architecture presents several issues including a single point of failure and problems of scalability.
- **Encryption:** BC uses technologies such as public and private keys to record data securely and semi-anonymously. Completed transactions are cryptographically signed, time-stamped, and sequentially added to the ledger.
- **Immutability:** The Blockchain was designed so these transactions are immutable, i.e. they cannot be deleted. No entity can modify the transaction records. Thus, Blockchains are secure and meddle-free by design. Data can be distributed, but not copied.
- **Tokenization:** Value is exchanged in the form of tokens, which can represent a wide variety of asset types, including monetary assets, units of data or user identities.
- **Decentralization:** No single entity controls a majority of the nodes or dictates the rules. A consensus mechanism verifies and approves transactions, eliminating the need for a central intermediary to govern the network.

- **Upstream Sector:** This is the section of the O&G industry that carries out resource exploration and extraction. The upstream service involves oil and gas exploration, extraction, or production of raw materials such as crude oil from wells. Other main activities include drilling contractors who own and operate drilling rigs, offshore oil/gas production facilities, oil service companies, and equipment manufacturers. The companies that carry out upstream oil and Gas processes operate under different contract requirements, each following its own performance metrics, and produce different deliverables. In upstream, there are too many equipment that are in daily use, which is very hard to keep track of and in consequence, there is a huge loss of time and money.

Bitcoin and its underlying blockchain technology increasingly impact all facets of society. Bitcoin’s status as digital gold is merely the tip of this technology. Figure 4 shows Bitcoin [8]. Although blockchain technology will for all time be associated



- Midstream Sector:** Companies in this sector are responsible for storing and transporting the extracted crude oil and natural gas resources. The midstream sector involves: (a) transportation services for safely shipping crude oil and natural gas using pipelines, tanker trucks, and heavy goods vehicles (HGV), (b) warehouse services for the temporary storage of crude oil at oil field terminals, and (c) refinement services to perform some initial processing of crude oil at the terminal. Storing and transporting hydrocarbon resources, managing expansive transportation networks, and paying dues to global regulations is what midstream oil and gas is all about. In midstream, there is a threat for faking transactions and contracts among third parties.
- Downstream Sector:** This is the segment where the resources are refined and produced into final products which are sold to end-users at gas stations and other points of sale. The downstream stage involves the refinement of the crude oil (at the oil refining facility) shipped from various oil production sites to make useable and marketable products such as gasoline, petrol, diesel, and liquefied natural gas. When the product meets the consumer, companies will have a lot more tools to manage quality, provide diversified services, and maximize revenues with reduced expenses and accelerated payments. Blockchain solutions have the potential to shake up the industry and improve performance from the production stage all the way through to distribution and sales. In downstream, there is a cause for concern regarding data security and integrity.

#### IV. APPLICATIONS OF BLOCKCHAIN IN OIL AND GAS

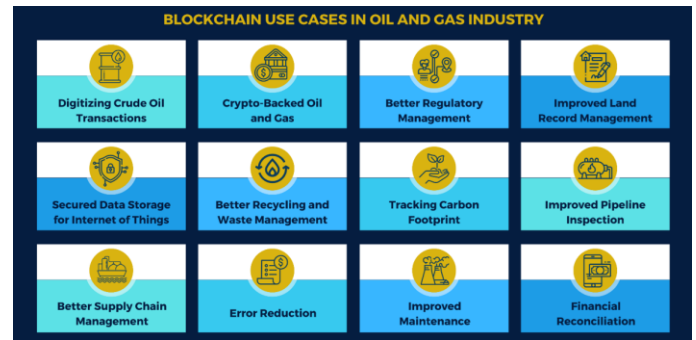


Figure 7: Blockchain use cases in the O&G sector [13].



Figure 8: Applications and opportunities of blockchain in the O&G industry [14].

Figure 6 shows the upstream to downstream workflow [12]. Many of the systems developed for automating business processes in the upstream, midstream, and downstream sectors have followed centralized architectures to store and process oil and gas-related data. The main challenges in each sector are, upstream: data leakage, midstream: data handling and replication, and downstream: integrity and data security. While the upstream companies typically face issues in heavy investment and cooperation among multiple parties, the other two sectors often must deal with ownership changes, transactions, and information exchanges taking place across multiple companies. Together, they make an ideal candidate for blockchain application.

Blockchain is an emerging technology with many interesting use cases in oil and gas. It has a range of compelling applications within the oil and gas industry. It is an immutable digital ledger of economic transactions, that is secured through cryptographic methods and can be programmed to record the transaction of anything of value. Figure 7 shows blockchain use cases in the O&G sector [13]. Potential areas of opportunity include land transactions (by verifying and eliminating fraudulent land dealings), oil and gas sales (facilitating large transactions), complex sourcing (minimizing transaction inconsistencies), capital projects (adhering to contract terms), and joint ventures (improving cost and revenue-sharing audits). Various applications and opportunities of blockchain in the O&G industry are shown in Figure 8 [14]. Blockchain has a range of compelling applications within the oil and gas industry, including the following [15]:

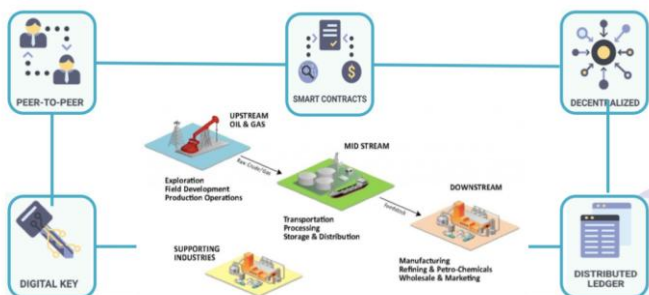


Figure 6: Upstream to downstream workflow [12].

- Storage:** Blockchain can store accounting data and transactions directly on sensor devices, which can reduce process time. It can improve data storage for the Internet of things (IoT), which is used to monitor operations and increase efficiency. As the sector uses more sensor technology, blockchain can store transactions and accounting data directly on these devices, which can reduce process time by connecting assets directly to services contracts. As sensor technology reaches its peak within the industry,

blockchain facilitates the direct storage of transactions and accounting data on these devices. The technology has the potential to accelerate digital transformation using sensors and cloud storage solutions. It can facilitate the direct storage of transaction and accounting data onto these sensors.

- *Blockchain Network:* Major oil & gas industry players are employing blockchain networks to drive forward unprecedented efficiencies with smart contracts, reduced market friction, and eliminating the need for intermediaries to carry out operations seamlessly. Each node in the blockchain network contains the same information, implying that once a transaction is committed on that network.
- *Contracts Execution:* Blockchain is quickly outgrowing from the crypto tag to become a smart contract facilitator. It facilitates embedding the contract in the transaction database for asset transfer. The contract is executed only once it is validated and deployed by all the parties. Smart contracts could add security and expediency to complex arrangements in the petroleum industry. They can introduce an additional layer of value by including timing and quality as factors in O&G deals. Blockchain can help with contracts that have high transaction values, are complex, or have low counterparty trust. By implementing smart contracts with distributed ledgers, operators can replace today's inefficient processes for handling payments, billings, statements and reports with one that is fast, reliable and transparent. To create a smart contract, terms are agreed upon by the entities involved, and the contract is then distributed on the blockchain. When the terms of the contract are fulfilled, the agreed-upon payment takes place automatically. Every contract would be distributed semi-anonymously across the entire network, making them safe from tampering or alteration. By using smart contracts and distributed ledgers to automate payments, well operators can simultaneously save money and improve their relationships with stakeholders.
- *Collaboration:* The oil and gas industry are a global leviathan, with a broad and diverse landscape where collaboration and open communication are the two main pillars. Blockchain can also transform contracting by providing a secure form of collaboration. It has the capacity to revolutionize contracting practices by offering a secure platform for collaborative endeavors. Implementing blockchain technology requires careful planning, collaboration with experts, and adherence to best practices.
- *Tracking:* Oil and Gas companies are now seeing the potential of blockchain technology to manage and track their resources more efficiently. Blockchain can facilitate real-time tracking of assets and enable sustainable practices like carbon credit trading. Tracking crude oil's path along the supply chain, as well as monitoring the conditions during storage, is crucial for companies to attain the highest quality of petroleum products. Personnel can easily keep track of the state of equipment using web apps connected to a decentralized network.
- *Hydrocarbon Tracking:* Blockchain technology can be used to track regulated substances effectively at each stage of the supply chain process. It can be utilized to track regulated substances like

hydrocarbons viably at each phase of the supply chain process. This can help to improve accountability in the business. The exploration and production of hydrocarbons involve drilling wells that are spread across long distances, in locations with different jurisdictions, some of which are in geopolitically unstable regions, or even offshore sites. This can help improve accountability in the industry.

- *Supply Chain Transparency:* Oil & gas operations are highly complex due to their vast supply chain spread across the globe, involving physical side suppliers, producers, and distributors. This enormous supply chain footprint can ultimately slow down the operations, such as transaction approval, as it involves multiple stakeholders operating in different time zones. Blockchain and smart contracts, along with IoT devices, can change the traditional supply chain for oil & gas with the benefits of transparency and immutability. Transparency is achieved by the distributed storage and the embedded smart contracts, enabling blockchain to govern the entire business process management.
- *Land Transactions:* One of the major blockchain use cases in the oil and gas industry is improved land record management. This is the most critical aspect for oil and gas companies. It involves systematically managing land sale records, which are worth millions of dollars in investments. To record and validate each transaction, the platform uses blockchain. Blockchain can verify land ownership and eliminate fraud. It can also provide an audit trail of land transfers, which can help reduce disputes and title mismatches. Blockchain could allow oil companies to easily complete transactions throughout the entire energy supply chain. Blockchain can help facilitate large transactions. Fraudulent transactions would be impossible to fabricate, just as it would be impossible to hide a transaction, as both would require tampering with every entity on the network. One of the most prominent blockchain oil and gas use cases is the digitization process of crude oil transactions.

## V. BENEFITS

Oil & gas companies that leverage blockchain can improve trade accuracy, increase scheduling and back-office efficiency, accelerate access to trade data, and shorten the working capital cycle. By using blockchain, companies can track materials and assets in real-time, save costs, and enhance collaboration. Blockchain assists in securing and simplifying oil and gas trading, shipment tracking, inventory control, documentation, and billing and payments. It can make processes more efficient, secure data, and create trust among different parties. Blockchain technology can be used in the oil and gas industry to improve efficiency, transparency, and accountability. It can optimize supply chains, reduce paperwork, and foster trust among stakeholders. Other benefits of blockchain in oil and gas include the following [10]:

- *Automation:* Like any other, the oil and gas industry have intermediaries, manual operations. Automation of such processes within the company and between contractors is the main goal of all services and departments. Blockchain can support the oil and gas supply chain by automating tasks and offering greater transparency.
- *Security:* This refers to the concerns that arise due to unauthorized access or attacks. The blockchain

technology cannot be easily hacked, especially with numerous computational algorithms. The advantages of blockchain in the oil and gas industry manifest through enhanced transparency, compliance, and data security. The cryptographic security of blockchain ensures secure transactions, particularly beneficial for cross-border trades. Using blockchain, crude oil transactions can be digitized that ensures enhanced security, improved transparency, and optimized efficiency.

- *Privacy:* Beyond removing the middleman or intermediaries, the blockchain is now working a trusted source where it promotes utmost privacy.
- *Trust:* Blockchain significantly boosts trust in the oil and gas industry. It ensures secure and transparent recording of data, like transactions and contracts, reducing fraud risk and improving efficiency. Blockchain technology has significantly impacted physical commodity trading by introducing transparency through its decentralized and immutable ledger, allowing stakeholders to track the supply chain and verify the origin and quality of commodities, thereby reducing fraud and enhancing trust. Blockchain's innovation promotes reliability and accountability, creating a more trustworthy and resilient oil and gas ecosystem. On top of boosting trust between companies and contractors/employees, such a blockchain network could also help cut down on hiring costs while ensuring improved job safety and performance.
- *Solutions:* As companies and investors across the oil and gas industry continue to operate in difficult times with compressed margins and reduced resources, blockchain provides real, difference-making solutions for the industry's most significant challenges today. Key benefits of the solutions include reduced cash cycle times, improved efficiency via lower overhead costs and fewer cost intermediaries, increased transaction visibility to help reduce the threat of tampering, fraud and cyber-crime, and the creation of transparent transactions by using shared processes and recordkeeping.
- *Transparency:* Blockchain is believed to have a potential to greatly impact the oil and gas industry by cutting down on operational time and costs while also introducing more transparency to the industry.
- *Decentralization:* One of the inherent qualities of a blockchain network is that it is decentralized, meaning it is not owned by a single entity, instead a network of computers (nodes) makes up a blockchain network. Blockchain can make this industry distributed and decentralized. Companies can make use of a decentralized network of IoT devices that trigger alerts and immediately notify corresponding personnel.
- *Error Reduction:* A major problem with human resources is the number of errors they make during data collection. Humans are prone to making an error, and even a single error in this regard can result in massive losses. However, as there is no way for this industry to get rid of all the human resources, it needs as much technological help as it can get. In many cases, companies can automate the data collection of maintenance data. This will significantly reduce the chance of errors.

- *Cost Reduction:* This refers to the cost reduction in operations when using blockchain technology. A decentralized blockchain system does not require a third party to take care of payment processes, unlike centralized financial infrastructures. So, the transaction speed is increased, and in turn, the cost is significantly reduced.
- *Lack of Tools:* This refers to the lack of tools within an organization to use the technology. The tools could be necessary hardware and software to run the blockchain technology along with the maintenance. To implement widely, it could be expensive to invest in the companies.
- *Immaturity of Blockchain:* This refers to the part where the blockchain technology has not been used for some time and still has flaws. Blockchain technology is immature, and this immaturity causes technical difficulties such as scalability, usability, and interoperability.
- *Complex Sourcing:* Blockchain can help minimize transaction inconsistencies. It simplifies the unwieldy and complex oil and gas supply chain processes by introducing transparency to the involved business processes.

## VI. CHALLENGES

Blockchain in the oil and gas industry presents both challenges and opportunities. The industry now faces its most challenging times, against a backdrop of reduced consumer demand, scarce resources and funding, and the smallest margin for error due to harsh regulatory policies. Other primary problems for blockchain for oil and gas include scalability, as blockchain networks need to handle large volumes of transactions, and interoperability, ensuring different blockchains can communicate with each other. Other challenges include the following:

- *Regulation:* The O&G industry is among the most heavily regulated in the world with protocols deriving from various regulatory authorities from environmental to taxation. Federal law regulates the operation of natural gas pipelines that provide long-distance transmission and local customer distribution. Regulatory authorities will be able to maximize visibility in the industry as all the transactional data is stored on a blockchain network which can be accessed in real time. Companies are struggling to comply with global regulations and to ensure that safety requirements are being met by every participant in the supply chain. Regulations can be enforced at every step in the technological process. Blockchain can help ensure compliance with contract terms.
- *Centralization:* A large portion of the existing systems is centralized, manual, and highly disintegrated which make them vulnerable to manipulation and the single point of failure problem.
- *Complex System:* Complexity is the degree of the participation of environment coordination, and it is measured by the number of parties that collaborate to make an impact. If you add to the complexity of compliance and regulation regimes, the large number of projects involving many contractors and subcontractors, you will have the world's most complicated document management system. The complexity of this process increases the number of delayed payments and litigation and causes persistent



tendency to accumulate errors and inconsistencies. The upstream O&G process is a complex process every step of the way: from management to negotiating agreements and payment processing, to approving performance results and sending products further down the supply chain. Petroleum contracts are often complex and can involve many different entities.

- **High Cost:** Equipment in the O&G sector costs from 125 to 500 thousand dollars, which in turn leads to an increase in the cost of goods for the final customer. Blockchain can improve audits for cost and revenue sharing. Companies are on a constant lookout for less costly and more effective ways of locating, extracting, and refining hydrocarbons to produce oil and gas products. Building new blockchain platforms and integration with the existing ecosystem of networks such as Ethereum can ultimately lower expenses and costs across the board.
- **Data Management:** The processes rely on manual entry, supervision, and are highly susceptible to security breaches and human error.
- **Water Management:** In the oil and gas industry, water management is a very complex and challenging issue due to the high volumes of water required, the hazardous nature of the wastewater, and the multitude of transactions of both clean and wastewater that need to be monitored. For oil and gas development operators, getting information about available source water is critical and time-consuming. In the water and wastewater context, the system of water flow is a network. Both the water and wastewater systems are decentralized networks.
- **Waste Management:** The horror of waste management in this industry is alarming. Most of the big companies do not have a proper waste management protocol in place. These wastes are dangerously harmful to the environment and the people.
- **Inefficient Supply Chain:** Another huge problem in the O&G sector is the lack of proper supply chain management. Every single oil or gas plant is huge in size and needs a lot of human resources to coordinate between all of the instances or elements.
- **Lack of Transparency:** Another huge problem is the lack of transparency in this industry. This is a huge burden the industry must deal with, and it is not capable of stopping all the corruption. There is no transparency at every stage of the company.

### CONCLUSION

Blockchain technology is worth considering for any application that requires a secure and transparent database and involves multiple parties. Because blockchain systems can simplify so many processes, large companies are developing infrastructure and software to support it. It has the potential to bring big changes to the oil and gas industry. The oil and gas industry uses state-of-the-art engineering solutions for oil and gas exploration but substantially lags behind in using innovative digital technologies. Although the applications of blockchain in the oil and gas industry have been promising, the actual implementation rate has remained low. Literature on the adoption of blockchain in the oil and gas industry is rare and success stories in the industry are rare. In spite of this, blockchain will be highly rewarding for oil and gas industry because it presents plenty of solutions for the industry. It also boosts efficiency and cuts unnecessary costs.

Careful analysis monitoring of evolving trends will tell if blockchain's future in oil and gas is transformative or transient. If the challenges that are present now in the field can be overcome, technology will have a bright future and will be able to change many aspects of the industry for a more technological future. The future of blockchain in the oil and gas industry is quite bright. More information about blockchain in the O&G sector can be found in the books in [16-19] and the following related journals:

- *Petroleum*
- *Petroleum Research*
- *Energy Reports*
- *Oil & Gas Journal*

### References

- [1] "Blockchain meets the oil & gas industry," February 2018, <https://executiveacademy.at/en/news/detail/blockchain-meets-the-oil-gas-industry/>
- [2] "Blockchain technology in oil and gas industry," November 2023, <https://wezom.com/blog/blockchain-technology-in-oil-and-gas-industry>
- [3] C. M. M. Kotteti and M. N. O. Sadiku, "Blockchain technology," *International Journal of Trend in Research and Development*, vol. 10, no. 3, May-June 2023, pp. 274-276.
- [4] "Blockchain," *Wikipedia*, the free encyclopedia <https://en.wikipedia.org/wiki/Blockchain>
- [5] S. Nakamoto, "Bitcoin: A peer-to-peer electronic cash system," <https://bitcoin.org/bitcoin.pdf>
- [6] "The beginning of a new era in technology: Blockchain traceability," <https://www.visiott.com/blog/blockchain-traceability/#:~:text=The%20Beginning%20of%20a%20New,money%20without%20a%20central%20bank.>
- [7] "The CIO's guide to blockchain," <https://www.gartner.com/smarterwithgartner/the-cios-guide-to-blockchain#:~:text=True%20blockchain%20has%20five%20elements,%2C%20immutability%2C%20tokenization%20and%20decentralization.>
- [8] "Helping the military adopt blockchain technology," <https://www.pioneeringminds.com/helping-military-adopt-blockchain-technology/>
- [9] "Blockchain in oil and gas," February 2023, <https://graymatters-inc.com/blockchain-in-oil-and-gas/>
- [10] "Blockchain in oil & gas," <https://www2.deloitte.com/us/en/pages/consulting/articles/blockchain-digital-oil-and-gas.html>
- [11] "Blockchain becomes the savior for oil and gas," August 2021, <https://pixelplex.io/blog/blockchain-oil-gas/>
- [12] "Blockchain solution (POC) for oil & gas industry and ERP integration," <https://www.iterontech.com/ethereum-developer-oil-and-gas/>
- [13] H. Anwar, "Blockchain in oil and gas industry," January 2021, <https://101blockchains.com/blockchain-in-oil-and-gas-industry/>
- [14] "Blockchain in oil and gas industry: Applications and challenges," [https://www.linkedin.com/posts/offer-thinktank\\_blockchain-in-oil-and-gas-industry-applications-activity-7226828273094127618-ntZE](https://www.linkedin.com/posts/offer-thinktank_blockchain-in-oil-and-gas-industry-applications-activity-7226828273094127618-ntZE)
- [15] "Unleashing innovation in oil & gas industry with blockchain: 11 top use cases & benefits," October 2021, <https://www.birlasoft.com/articles/blockchain-oil-gas-industry-use-cases-applications>
- [16] M. N. O. Sadiku, *Blockchain Technology and Its Applications*. Moldova, Europe: Lambert Academic Publishing, 2023.

- [17] U. Kishnani, N. Noah, and S. Das, *Blockchain in Oil and Gas Supply Chain A Literature Review from User Security and Privacy Perspective*. SSRN, 2023.
- [18] G. Blokdyk, *Blockchain in Oil and Gas a Clear and Concise Reference*. Emereo Pty Limited, 2018.
- [19] S. Saraji and S. Chen, *Sustainable Oil and Gas Using Blockchain*. Springer, 2023.

#### ABOUT THE AUTHORS

**Matthew N.O. Sadiku** is a professor emeritus in the Department of Electrical and Computer Engineering at Prairie View A&M University, Prairie View, Texas. He is the author of several books and papers. His areas of research interest include computational electromagnetics, computer networks, and marriage counseling. He is a life fellow of IEEE.

**Philip O. Adebo** is an instructor at Texas Southern University. He completed his PhD in Electrical and Computer Engineering, Prairie View A&M University with emphasis on power systems. His research interests include power systems, renewable energy, microgrids, smart-grid systems, restructuring power systems, and optimization of power systems.

**Janet O. Sadiku** holds bachelor's degree in nursing science in 1980 at the University of Ife, now known as Obafemi Awolowo University, Nigeria and master's degree from Juliana King University, Houston, TX in December 2022. She has worked as a nurse, educator, and church minister in Nigeria, United Kingdom, Canada, and United States. She is a co-author of some papers and books.