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Blockchain Technology: Its Impact on Energy Efficiency and Trade

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by

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Blockchain Technology: Its Impact on Energy Efficiency and Trade

Abstract

Distributed ledger technology, known as the blockchain, is considered a promising system for different applications and use cases such as finance and marketing, education, startups, healthcare, government, supply chain, and also energy. Blockchain provides a distributed peer-to-peer network for non-trusted members to interact with each, without existing any authority as a trusted agency. Nowadays, energy industries are technologically very developed and sophisticated. The oil and gas industry has been recently improved looking to utilize Big Data, the Internet of Things and Artificial Intelligence within its key processes and daily tasks. However, some classic long-established methods are still used to carry out enhance energy production (efficiency), management, demand response, storage, and trading. Blockchain can be an effective choice to update these traditional methods. This paper attempts to provide a review on the implementation of blockchain technology in the energy industry that faces some big problems with current infrastructure. Energy inefficiency, environmental concerns, energy storage, inequality, and its trading issues are some of these problems that need to be solved. The journey of energy from the source to the end-user consists of complicated distribution networks that takes consumer further away from the source. Energy efficiency loss, CO_2 emission, damage equipment, reliability issues, and safety concerns could be the worst drawbacks during this journey. A centralized traditional system can be replaced by blockchain technology as a distributed, decentralized, and public ledger. This paper also discusses different types of blockchain classified depending on the user demand. Focusing on oil and gas industries, the main areas that blockchain can be applied such as database management, trading, regulatory, and security in data transforming are presented in the concept of this study. Therefore, this thesis provides a chamber

of information shed light on the industry to recognize the benefits of using this technology regarding data reliability, time, and cost efficiencies.

Keywords: Blockchain, Energy efficiency, Energy trading, Data security

Blockchain Teknolojisi: Enerji Verimliliği ve Ticaretine Etkisi

Özet

Blockchain olarak bilinen dağıtık yapı teknolojisi, finans ve pazarlama, eğitim, sağlık, denetim, tedarik zinciri ve ayrıca enerji gibi farklı uygulamalar ve kullanım durumları için gelecek vadeden bir sistem olarak kabul edilir. Blok zinciri teknolojisi, güvenilir olmayan üyelerin herhangi bir yetkisi olmadan etkileşime girmeleri için dağıtık eşler arası bir ağ sağlamaktadır. Günümüzdeki enerji sektörü (geleneksel ve yenilenebilir) teknolojik olarak gelişmiş ve ilerlemiş durumdadır. Petrol ve doğalgaz endüstrisi günümüzde Büyük veri, nesnelerin interneti ve yapay zekadan faydalanmak amacıyla gelişmeye açık bir konumdadır. Bununla birlikte, enerji üretimini (verimliliğini), yönetimini, depolamayı ve ticaretini geliştirmek için bazı klasik köklü yöntemler bulunmasına rağmen blockchain bu geleneksel yöntemleri güncellemek için etkili bir yöntem olabilmektedir. Bu bağlamda bu çalışmada, enerji sektöründe karşılaşılan mevcut altyapı sorunlarını gidermek amacıyla blockchain teknolojisi uygulamasına ilişkin kapsamlı bir inceleme ve değerlendirme yapılmaktadır. Şuanki enerji sektöründe enerji verimsizliği, CO_2 emisyonu, enerji depolama, güvenlik, güvenilirlik ve ticaret sorunları çözülmesi gereken problemlerden bazılarıdır. Bu problemler kullanıcı talebine bağlı olarak sınıflandırılan merkezi geleneksel sistem, dağıtık ve merkezi olmayan blockchain teknolojisi ile değiştirilebilmektedir. Bu çalışma kapsamında, özellikle petrol ve doğalgaz endüstrisinde veri tabanı yönetimi, ticaret, düzenleme ve veri dönüşümü güvenliği gibi blockchain sisteminin uygulanabileceği ana alanlar sunulmuştur.

Sonuç olarak, bu çalışma ile blockchain teknolojisinin veri güvenilirliği, zaman ve maliyet verimliliği açısından önemini vurgulayarak sektöre ışık tutmak amaçlanmaktadır.

Anahtar Kelimeler: Blockchain, Enerji Verimliliği, Enerji Ticareti, Veri Güvenliği

My Family…

Acknowledgment

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

EV	Electric Vehicle
PoW	Proof of Work
PoS	Proof of Stake
PoA	Proof of Activity
PBFT	Practical Byzantine Fault Tolerance
FBA	Federated Byzantine Agreement
M&V	Measurement and Verification
IoT	Internet of Things
HDAC	Hyundai Digital Asset Currency
TEPCO	Tokyo Electric Power Company
AI	Artificial Intelligence
ML	Machine Learning
P2P	Peer to Peer
BP	British Petrolleum
CNE	Chilean National Energy Commission
IT	Information Technology
OT	Operational Technology

Chapter 1

Introduction

Nowadays, energy efficiency in the energy sector, CO_2 emission, energy storage, safety, reliability and trade problems are some of the problems that need to be solved. In the scope of this study, it is evaluated that blockchain technology will contribute to solve the indicated problems. First of all; to comprehend the technology, it is necessary to start with the definition of the concept of blockchain.

The blockchain term was stated for the first time by Satoshi Nakamoto in 2008. Different researchers also put forth various definitions [1,2,3,4,5,6,7,8,9]. For instance, Tian describes blockchain as "a non-traditional secure database" [5]. Iansiti and Lakhani (2017) define the blockchain technology as a distributed database.

The blockchain technology appears as a system that will eliminate intermediaries for many sectors. Blockchain is seen as an effective choice to update traditional methods. Thanks to this technology, economical solutions emerge in terms of time, labor and cost. In today's world, where science and technology have developed rapidly, ignoring technological developments causes us to be behind the times. Time and cost are very important for today's individuals and these two issues are taken into consideration in the transactions. Speed and flexibility come into prominence in transactions. In this context, the business and transaction process of blockchain technology is making progress rapidly from banks, exchanges, energy companies and trading platforms to customers and energy consumers. Although blockchain technology has many advantages in theory, it has features that need to be developed technologically and legally. Information on this subject will be explained in detail in the following sections.

The topics aimed to be revealed in the study are listed below:

1) Today, the test and development studies of blockchain technology are carried out in the banking and energy sector. Within the scope of these studies, it is aimed to carry out transactions automatically between the producer and the consumer, with a decentralized system without a need for third parties.
2) One of the most important goals of blockchain technology is to make the multi-layered system in the energy sector, which affects all individuals and consists of a detailed hierarchical system, more simple and transparent.
3) Nowadays, blockchain technology in the energy industry is not well understood and there are some misunderstandings. This new technology is not well understood because it is not used widely enough. It is aimed to eliminate the question marks by revealing the advantages and risks.
4) Blockchain technology has different practice areas in the energy sector. Based on the purpose and usage areas of blockchain technology, this study aims to examine and critically reveal its reflections, especially in the energy sector.
5) The advantages of blockchain technology to the oil and natural gas industry include transforming the company into a cost-effective situation and ensuring the auditability of the system. Besides, there are also many challenges in the regulation and transformation of the system, especially technological; as implementation is still at an early stage. In order to understand what these challenges are, the blockchain technology and current business are explained comparatively.
6) Since the establishment of a blockchain system on a legal basis will enable businesses that want to use the system to act boldly, it is considered that it will be beneficial to conduct legislation on this issue.

Chapter 2

Blockchain Technology

Economists and traders have constantly sought and tried systems that could be alternatives to existing payment systems. For example, barter used in ancient times has become popular again. The search for alternatives to money still continues. Because the high commissions taken in money transfers through banking or intermediary institutions have brought extra costs. Moreover, this system also has security vulnerabilities. There is a lot of fraud and theft in trade. In fact, the concepts known in the world of informatics are distributed networks, encryption, sending information securely and confidentially in a virtual environment, software to perform transactions automatically, chain structures, databases. At the end of the search of bankers and economists, they came together and created a brand new payment system. With the conceptual combination of these elements by Nakatomo, the concepts of blockchain and crypto money were born. New concepts that were not known before, such as different virtual currencies and digital signatures, came into life. Factors such as a financial interest in the commercial environment, the parties that do not trust each other and payment intermediaries have been the reason for the use of the blockchain method in this application.

In order to define blockchain technology, it is necessary to explain the concepts of automation, big data and digitalization first. The word automation, which has entered our lives with the development of technology, appears in many fields such as electronic devices, scientific studies, and the production sector. The meaning of this word is expressed as self-acting. The system that gathers and controls the works performed by machinery and human power under a single roof is called automation. The system, which provides a more efficient and economical working opportunity, gives a global chance in production. Therefore, it also means an important technological structure for many different sectors. Automation is a concept in which machines and human factors act together. It is a term that enables the devices that

make up a whole to work simultaneously. Thanks to automation, businesses can reach a great speed and power in the sector they serve. It is a very useful mechanism because it minimizes the probability of error.

Automation finds effective solution methods for detailed measurement, efficiency saving time and energy. Automation systems are used in many fields today.

- Manufacturing sector
- Electronic device manufacturing
- Mobile phones
- Scientific studies

Today, automation systems have become indispensable for life in many different fields as in the examples. Digitization is simply the conversion of analog data to digital format. Since it is easier to process and store all kinds of information digitally in today's world, all kinds of business lines are becoming increasingly digital. One of the biggest benefits of digital transformation is that digital documents are easier to find, send, receive, store, save time and effort. Thanks to the faster and more precise results of digitally processed data, important decisions can be taken based on more accurate and absolute data. Depending on the digital data they obtain, companies can make much more accurate predictions about the products and services their customers expect from them. However, a must of this transformation is collecting data and processing the collected data correctly. Various digital solutions are available for this. Both software and consultancy provide rapid results digitally. The importance of digitization has also become evident in the Covid-19 pandemic. Curfews and quarantines announced around the world have caused companies to make rapid strides in digitalization. Thanks to digitalization, most people were able to keep their workplaces alive during the times when there was no one on the streets [10]. As a result, digitalization has emerged as a necessity of this age. Figure 2.1 shows the percentage distribution of investments in digital technology.

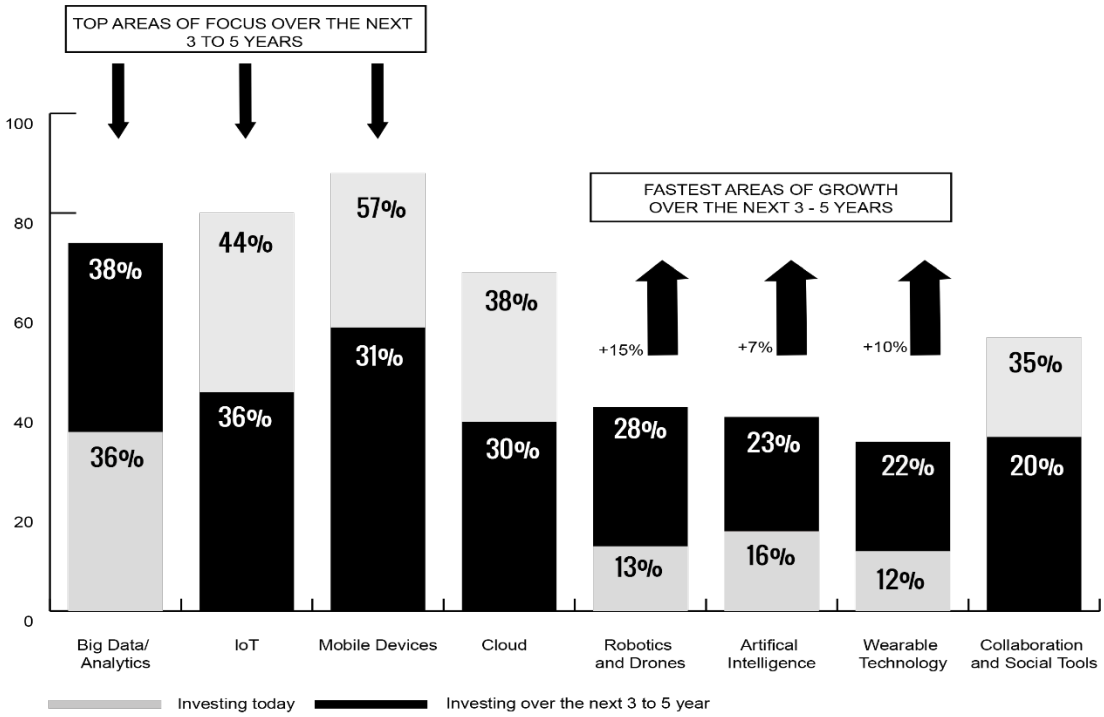

Figure 2.1: Investments in digital technology (reproduced from [11]).

As shown in Figure 2.1, huge investments are made in digital technologies in many areas such as electronic devices, wearable technologies, artificial intelligence, cloud storage. In addition, robots, drones, artificial intelligence and wearable technology are the fastest-growing fields. After examining the concepts of automation and digitalization, it is necessary to examine the word big data.

Big data is the form of all the data collected from different sources and transformed into a meaningful and workable form. Big data consists of a large amount of information such as logs of web servers, Internet statistics, information from sensors. When interpreted with the right analysis methods, big data enables companies to take their strategic decisions correctly, manage their risks better and make innovations. Most of companies still continue to make decisions based on the data they have obtained through conventional data warehouses and data mining methods. However, dynamically predicting consumer trends requires analyzing big data and acting accordingly. Big data emerges as a term that includes many subjects such as the creation, storage, flow and analysis of this big data, which is difficult to process with traditional database tools and algorithms. As the data is too large for classical databases to handle, the growth rate of data exceeds a computer or a data storage

unit. All of the work such as processing and transferring large-scale big data is called Big Data.

There are six main components in the formation of the big data platform. These are variety, variability, velocity, volume, verification, and value. It is formulated as 6v.

- *Variety*: Every newly produced technology can produce data in different formats. It is necessary to analyze various kinds of "Data Types" from phones, tablets, computers and integrated circuits.
- *Velocity*: The production speed of Big Data is at very high levels and is increasing. Data that produced faster results in an increase in the number and variety of transactions that need this data at the same rate.
- *Volume*: It is necessary to consider "large systems" and the capacities called "large" currently in use and to evaluate how they will cope with larger data. It is necessary to establish how the technologies of data archiving, processing, integration, storage, etc. will cope with this large volume of data.
- *Verification*: In this information density, being “safe” during the flow of data is another component. During the flow, it must be visible to the right people or remain confidential and be followed at the security level it should be.
- *Value*: The most important component is that the data creates value. After the data production and processing layers of Big Data, it should create added value for the institution. It should affect the decision-making processes instantly and help in making the right decision. For example, a state institution that takes strategic decisions on health should be able to instantly see the distribution of the region, province, district, diseases, drugs and doctors.
- *Variability*: This concept reveals the processing of Big Data and the changes of data during the cycle. The 6v formula is shown in Figure 2.2 below.

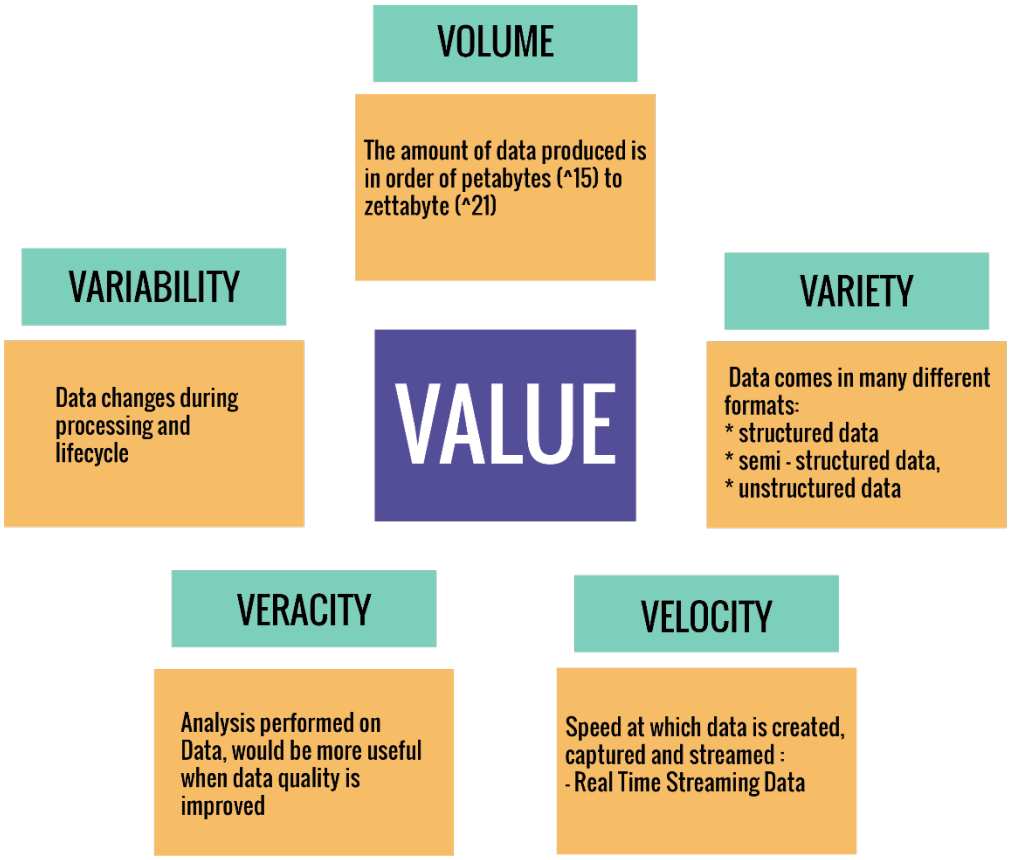

Figure 2.2: 6v Formula (reproduced from [12])

As seen in Figure-2.2, big data expression occurs as a result of the combination of six concepts starting with the letter “V”: value, variability, volume, veracity, velocity and variety. The elements that make up the concept of big data, which directly contribute to the decision-making process, should also be examined with great care by businesses.

Big data is used in many fields, especially in the health, education, trade, banking and energy sectors. Using smart grids and meters, energy companies are working to store and process data about their subscribers' individual usage. In the oil field, when we look at the position of big data, we encounter the following slogan: 'Big data is the oil of the new economic order.'

Along with the concepts of big data, digitalization and automation mentioned above, blockchain technology has also taken its place in our lives. When the definitions made in the introduction are examined as a whole, blockchain technology is a peer-to-peer contact, and it can be expressed as a reliable and transparent database that

allows all peers to see the transaction history. Figure 2.3 below shows the functioning of the blockchain system mechanism.

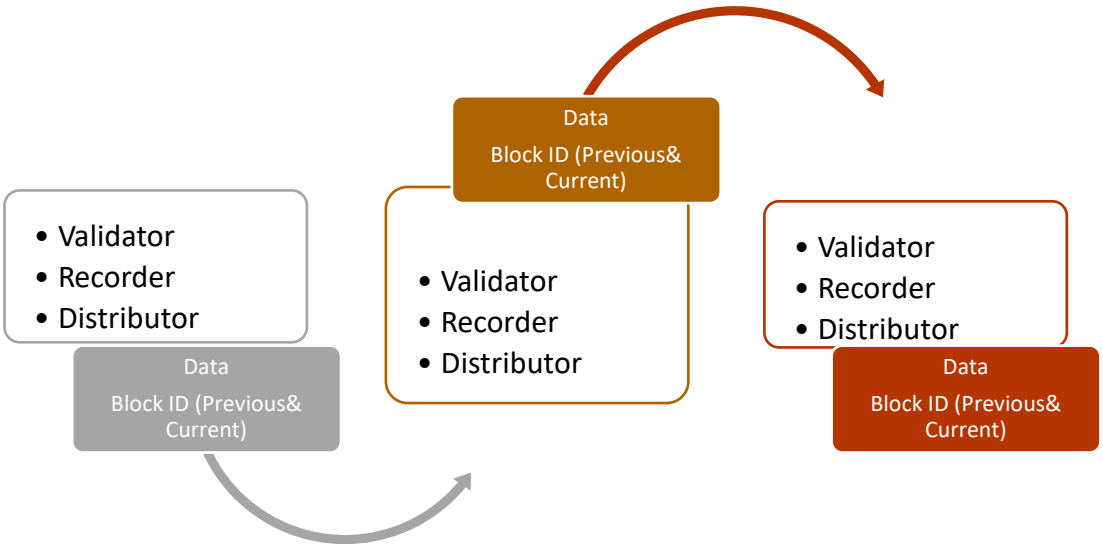

Figure 2.3: Blockchain System Mechanism (reproduced from [13])

When Figure 2.3 is examined, the mechanism of linking the validator, recorder, distributor, data, previous block number and current number with other blocks can be seen. The working principle of the system can be exemplified by the intertwining of the rings of a chain. In case of any change, this situation is easily noticed.

2.1 History of Blockchain Technology

Today's blockchain applications can be divided into three wide categories based on their development phase, namely 1.0, 2.0 and 3.0 phases. The “Blockchain 1.0” category includes virtual (crypto) currencies such as bitcoin (e.g. euro or dollar) that can be used as alternatives to real currencies. By this time, Bitcoin continues to be the most well-known blockchain application for the public and is getting more and more popular.

The next stage of "Blockchain 2.0" development is to enable smart contract models. "Smart contract" represents a digital protocol that automatically executes predefined processes of a transaction without requiring the involvement of a third party (e.g. a bank). For example, it may be possible to create a fully automatic smart contract

between an energy producer and a consumer that regulates both supply and payment independently and securely. If the customer is unable to pay, the smart contract will automatically set the power supply to be suspended until payment is received, provided that the parties have agreed to include such a mechanism in their contract in advance. This development poses a threat to the traditional business models of banks.

The next generation of blockchain named "Blockchain 3.0" remains a vision for now. Blockchain 3.0 is the stage where the smart contract concept was developed to create decentralized organizational units operating with a high degree of autonomy and based on their own laws [14].

2.2. Classification of Blockchain Systems

2.2.1 Private Blockchain

Private blockchain refers to a blockchain managed by only one person. It is almost impossible to tamper with the private blockchain system. This makes the system easier to audit but does not make it completely reliable [15].

2.2.2. Public Blockchain

The public blockchain, unlike the private blockchain, is a blockchain where anyone can actively participate in the system. Many operations can be done, such as reading data, validating, etc [16].

2.2.3. Consortium Blockchain

This system is a hybrid of the two systems mentioned above. While anyone can access the data in the public blockchain system, everyone can not access the data in this system. While only one person can access the system in the private blockchain, selected people play a role in this system. This is determined by the rules [4].

Companies may want to build their applications on the three types mentioned. In a public blockchain, the participants are unknown in advance. Bitcoin and Ethereum

are examples of this. In private blockchain systems, all participants know and are identified in advance. Some advantages of private blockchains are that they are relatively simpler and less costly. Therefore, banks and payment service providers use this type. On the other hand, in the consortium blockchain, the authority to review, audit and transact on the blockchain can only be done by certain individuals. These types of technologies differ in their accessibility, management permissions, and operating characteristics, so each blockchain type is suitable for different applications and use cases.

Figure 2.4 below shows a comparison of public, private and consortium blockchain systems.

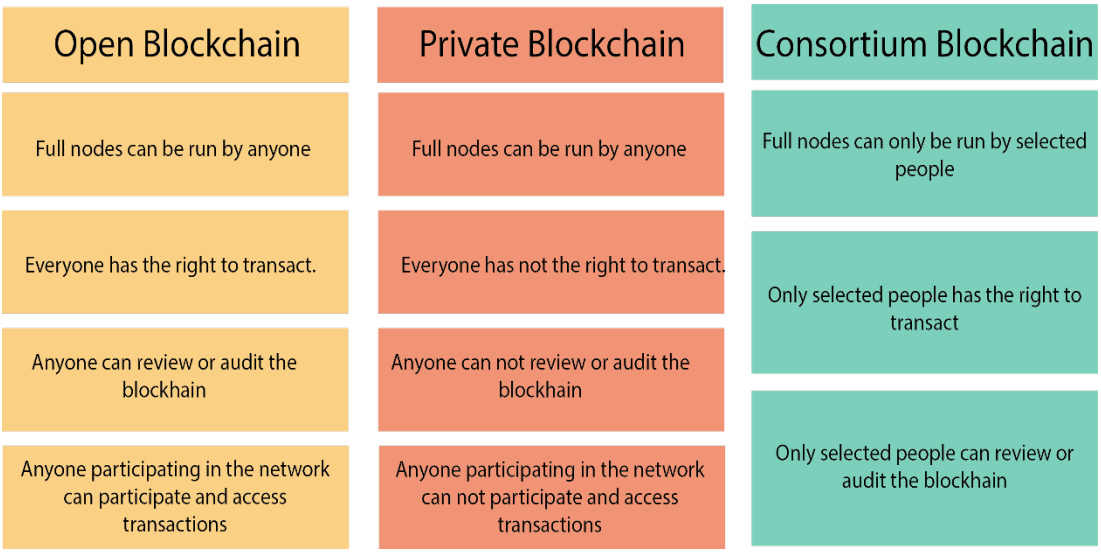

Figure 2.4: Types of Blockchain Technology Networks (reproduced from [17])

As seen in Figure 2.4, classification can be made as a public, private and consortium blockchain according to the status of joining a network and accessing transactions. Although there is a triple separation in network types, it is also observed that there is often a dual separation as public and private.

Regarding private blockchain technology; the issues are standing out such as; the relatively limited access to the system, the low energy used, the high speed and efficiency, the provided security with pre-approved participants, possibility of making changes to the blocks, users taking part in the reconciliation process, the

determination of the reconciliation by a central system and taking place the approval of the transaction within milliseconds.

Regarding public blockchain technology; the issues are standing out such as the access to the system being open to everyone, the high energy used, the low speed and efficiency, the provided security by consensus algorithms, being almost impossible to change the blocks, the anonymous consensus process, the determination of the consensus done by a distributed system and taking place the approval of the transaction within minutes.

Regarding the consortium blockchain technology; the issues are standing out such as relatively limited access to the system, low energy used, high speed and efficiency, security provided with pre-approved participants, the possibility of making changes to the blocks, users involved in the reconciliation process, the reconciliation determined by a semi-central system, the approval of the transaction taking place within milliseconds.

Since the rapid rise of cryptocurrencies such as Bitcoin or Ethereum, the topic of blockchain has also become the center of interest. Many times, the functionality and features of blockchain technology have been significantly reduced or described as incomplete. Therefore, it is also necessary to understand what a blockchain is not. The blockchain system, which means that different blockchains cannot communicate with each other, i.e. cannot exchange data, is not Bitcoin and is not equal to the Bitcoin blockchain. Bitcoin is a cryptocurrency that uses blockchain-based on technology. Thus, it is an application on a blockchain, but it is not the only conceivable application scenario. Additionally, Bitcoin is not the only cryptocurrency as there are many cryptocurrencies around the world. And a blockchain doesn't definitely need a currency, especially private blockchains that don't usually use a cryptocurrency. On public blockchains, however, these currencies serve as an incentive mechanism to attract more participants and they are rewarded with "monetary" values for correct behavior or computing power within the blockchain. A blockchain system is not the same as a database.

The main strength of the blockchain is its distributed structure technology. A blockchain is not a "single" blockchain. There are several hundred different blockchains that differ in their consensus mechanisms or access. Additionally, most blockchains operate completely independently of other blockchains, and this feature sets them apart from traditional databases. In centralized structures, security challenges arise as more participants have the right to change their data records. On the other hand, a blockchain provides increased security as more participants check each other with a consensus about the accuracy of new data entries. Blockchains are not the only solution either. Blockchains, only in combination with other digital technologies, can generate high added value as a reliable infrastructure

To give an example from the energy sector; Generating facilities such as photovoltaic rooftop units can document the amount of electricity produced directly on a blockchain via an internet-connected terminal device. This provides unalterable documentation of any electricity produced or consumed. However, it is very important to make sure that the devices entering data into the blockchain are set up correctly. Probability checks, namely data analytics, can also help identify sources of misinformation. Otherwise, there is a danger that incorrect data will be written to a blockchain that does not ensure real conditions [18].

2.3 Blockchain Composition

Blockchain is a data structure consisting of a time series of blocks. A block is a collection of data containing related information and records and is the basic unit of the blockchain. The data structure of the blockchain mainly consists of a block header and a block body. The block header is the hash of the previous block used to link the previous block and to ensure the integrity of the underlying blockchain. The block body contains the main information of the block (such as transaction information). This information, together with the hash of the previous block and the random number, creates the hashed hash of the current block. Figure 2.5 shows the elements of the blockchain system and their connections.[19].

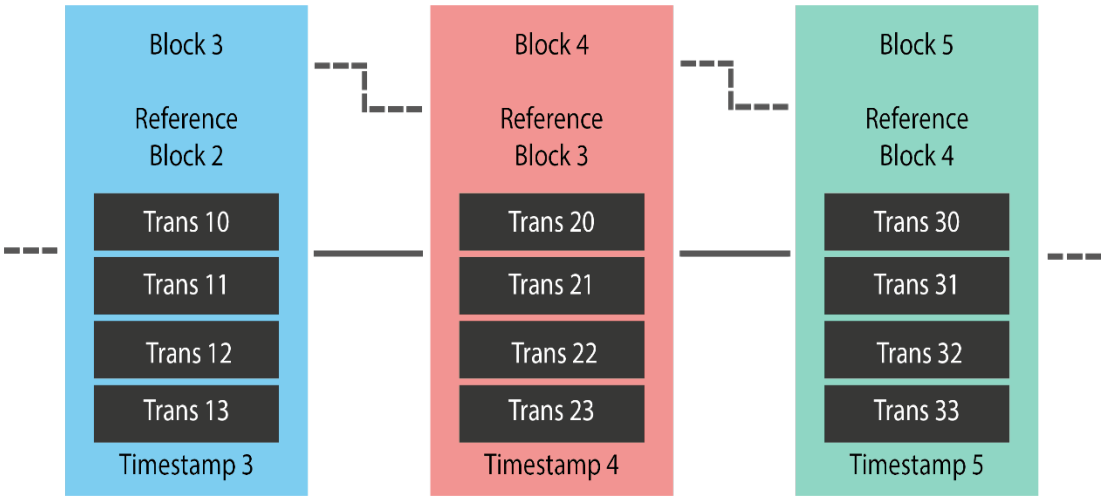

Figure 2.5: Blockchain Composition (reproduced from [19].

Figure 2.6 shows how criterias such as data, transaction information and time stamp are specified in the inter-block connection.

In the Bitcoin implementation scenario, each block data records the system transaction data information (Trans in Figure 2.5) published by the participating nodes at a certain time interval. Transaction information includes sender and receiver ID, transaction amount, transaction duration, and other additional information. In addition to transaction data, each data block also contains the block ID, timestamp (Timestamp in Figure 2.5), link relationship with a previous block (Reference in Figure 2.5), and so on. The blocks are then linked together in a chain that records all previous transaction information in the entire network. These blocks of data are published to the entire shared network in real-time. Once approved and added to the chain, they are very difficult to reject and change, thus they ensure the transparency and reliability of the entire database. As can be seen in Figure 2.6, any change that is attempted to be made in the system can be observed clearly [20].

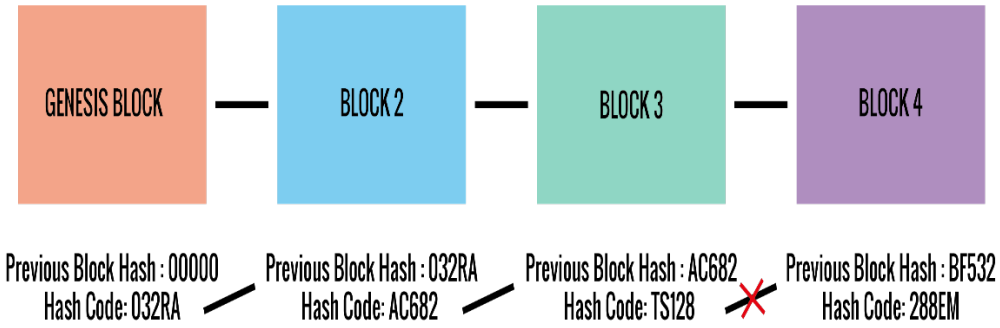

Figure 2.6: Blockchain technology (reproduced from [17])

When Figure 2.6 is examined, it is shown how the desired data change in a block is. The hashcode seen in Block-3 was incorrectly rated in the previous block hash code section in Block-4, and the difference was shown.

2.3.1 Blockchain's Working Mechanism

It is possible to explain the working mechanism, reliability and intangibility of the blockchain system with an example. When we think of the blockchain chain as a notebook each page of the notebook represents a block. In each block here, the data packet 'hash pointer' is expressed as the serial number of the notebook. Each page of the book is added with the same serial number as the next page and creates a locked system. Thus, a blockchain is formed by combining every page with the same serial number, and each block added to the chain contains all the previous information. When the blocks are seen and approved by all users, a new block is added to the chain. When a new block is created in order to change the existing information of the chain, the block must have a different serial number. Therefore, it is necessary to change the serial numbers of all blocks that occurred before and will occur later. Changing the serial number of a block requires superhuman speed when blocks are constantly added to the chain and approved by other users. Therefore, the blockchain system is considered to be a very reliable system in this respect [21]. The working mechanism of blockchain technology is given in Figure 2.7 and Figure 2.8.

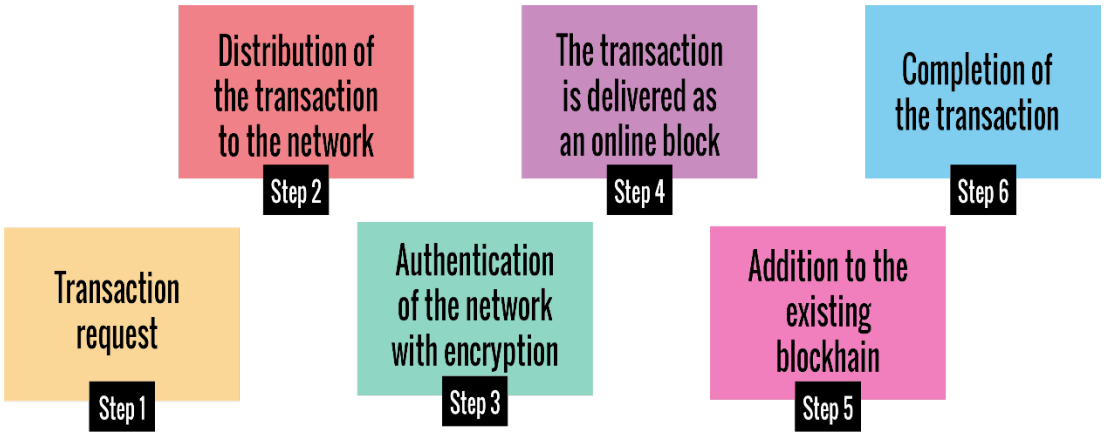

Figure 2.7: Working mechanism of blockchain technology. (reproduced from [22]).

As seen in the figure above, the completion of the process is seen at the end of a six-step mechanism. According to [22], if two different units want to make a transaction (Step 1), a new block is created (Step 2). After encryption, this information is transmitted to other members in a distributed structure. Then members check whether the transaction is correct. To do this, different hash values are used. If a change is attempted, an error will occur (Step 3). If there is nothing against the normal flow, the blocks are connected to each other. (Steps 4 and 5). Finally, if both parties confirm the transaction, it means that the transaction is successful (Step 6).

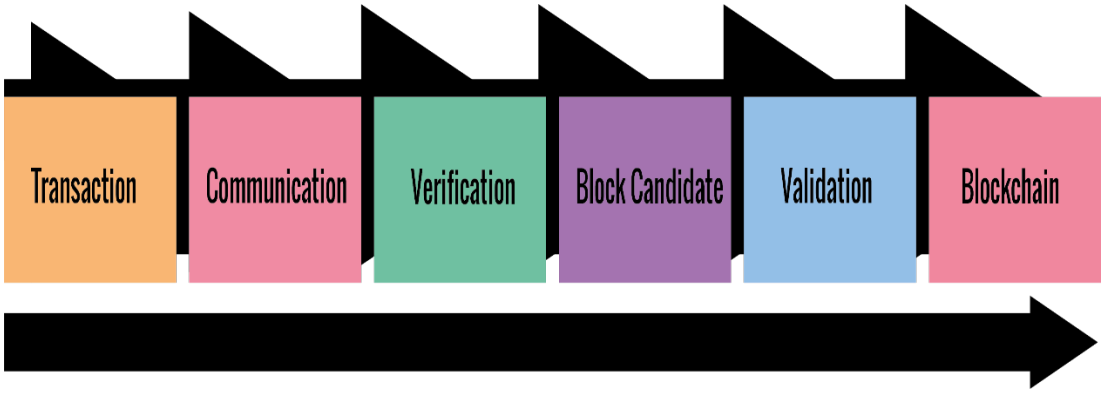

Figure 2.8: Blockchain Function (reproduced from [23]).

In Figure 2.8, transaction, communication, verification, block candidate and validation of the process are expressed with a visual. With the intertwining of the rings of the chain, the concept of the blockchain emerges.

2.3.2 Blockchain's Technology Architecture

Blockchain's Technology Architecture consists of:

- Data layer,
- Network layer,
- Consensus layer,
- Incentive layer,
- Contract layer and
- Application layer

The data layer contains basic data blocks and timestamps, etc., and stores all transaction data and information records in blockchain format. The network layer mainly includes peer-to-peer (P2P) network technology (also known as point-to-point transmission technology or peer-to-peer network technology), propagation mechanisms, and authentication mechanisms. It will complete consensus algorithms, encrypted signatures, and data storage. The consensus layer basically includes a consensus mechanism that allows nodes to agree on the effectiveness of block data in a decentralized system where decision power is highly distributed. The incentive layer integrates economic factors with blockchain technology, mainly including the mechanisms of granting economic incentives and the distribution mechanism. The purpose of incentives is to attract participants to contribute their computing power. The contract layer basically includes various scripting codes, algorithmic mechanisms and smart contracts and determines regulated and auditable contract properties. The application layer, on the other hand, contributes to the programming of all available data [19].

It is necessary to deal with the consensus algorithm in detail, along with explaining the terms it contains.

Consensus Algorithm: This algorithm is a process used in computer science to reach agreement on a single data value among distributed processes or systems. Therefore, the importance of consensus mechanisms in the blockchain is to simplify and ensure updating a process or a state that a distributed cluster performs state transitions under its rules. There are many consensus algorithms used by the blockchain network. The most common is proof-of-work. Examples of other leading consensus algorithms are proof-of-stake, practical Byzantine fault tolerance algorithm (PBFT), delegated proof-of-stack algorithm (DPoS), authorized stack proof algorithm and federated byzantine algorithm [24].

Figure 2.9 shows the comparison of proof of work and proof of stake, Figure 2.10 shows the levels of algorithms meeting these criteria according to some criteria, and Figure 2.11 shows the table of different blockchain areas.

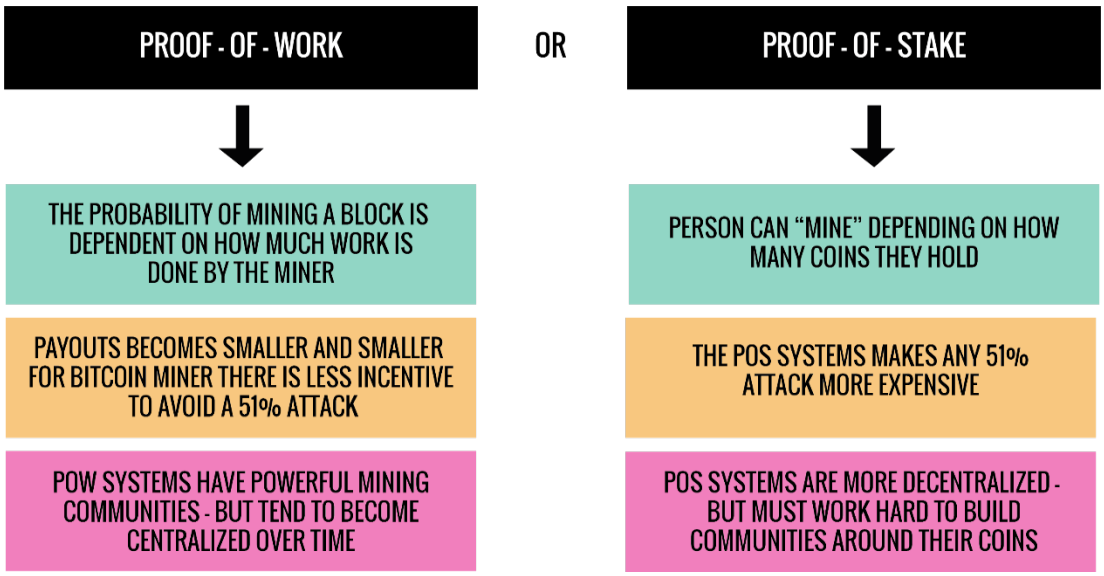

Figure 2.9: Comparison of PoW and PoS (reproduced from [25])

As seen in Figure 2.9, mining a block for PoW depends on how much work is done by the miner, while for PoS it depends on the amount of share it holds. While the PoW system tends to be centralized, the PoS system is more distributed.

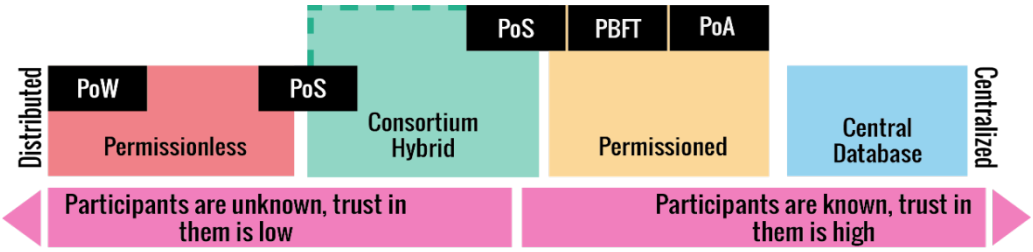

Figure 2.10: Consensus algorithm used based on blockchain domain (reproduced from [26]).

As seen in Figure 2.10, algorithms can be classified according to whether the participants are known or not, the level of trust to participants, and whether algorithms are centralized or distributed. When the proof of work and share algorithms are examined, it is observed that they are in a distributed structure, the participants are not known, and the trust is low for this reason. In other algorithms, there is an exact opposite situation. It is seen that it is a centrally managed system, the participants are known, so the trust is at a high level.

Table 2.1: Summary table of different Blockchain areas [26].

Characteristics	Permissionless / Public	Permissionless / Public	Permissioned / Public	Permissioned/ Private
Consensus	Pow	FBA	PoS	PBFT/Multi-signature
Anonymity of the user	High	Medium	High	Medium
Immutability	High	Medium	Medium	Medium
Scalability	Low	Medium	Medium	Medium
Privacy	Low	Medium	Low	Medium
Examples of Platform	Bitcoin, Ethereum	Ripple Stellar	Ethereum Casper	Hyperledger Fabric Tobalaba Tendermint
Energy Use Case	Yes	No	No	Yes

When Table 2.1 is examined, it is seen at what level these algorithms correspond to criteria such as consensus, user awareness, immutability, scalability, privacy, platforms used, and energy use cases. Especially in the proof-of-work algorithm used on Bitcoin and Ethereum platforms, user awareness and immutability are high, scalability and privacy issues are low. In the proof-of-stake used by Ethereum Casper, user awareness is high, immutability and scalability are medium, and privacy is low.

2.4 Advantages of Blockchain's Technology

Considering the history, the usage areas and components of blockchain technology, the five key features that make blockchain technology convenient are expressed as follows.

1- Decentralized: With Blockchain technology, the central systems used in most transactions have been replaced by a decentralized management system. In simple terms, the central system consists of the main unit that stores all the data. If needed, it is necessary to interact with the central unit in order to access that data. The current banking transactions can be given as an example of the central system. Although central systems have been used for many years, it is known that it has some risks and security problems. The main problem is that all data is stored in one place and becomes an open target for hackers. In addition, if a unit in the central system is corrupted or inaccessible for any reason, no one can access the stored data. On the other hand, Blockchain technology uses a decentralized system that everyone can access. Users can easily access their own data without the need for a center. Figure 2.11 shows the centralized and decentralized system.

a) Centralization b) Decentralization

Figure 2.11 a-b: Basic representation for centralized and decentralized systems.

Central systems (a) have a basic authority to show the truth to other participants in the network. Only authorized users or institutions can access the transaction history and approve new transactions. Decentralized systems (b), on the other hand, have no authority to show the truth to other participants in the network. Every participant in the network can access the transaction history or approve new transactions.

2-Transparency: One of the most important advantages of blockchain technology is that the system is transparent. In this system, everyone has their own complex password username. The flow between accounts can also be followed by looking at the user name, not with real identity information. For example, instead of 'Ahmet transferred 1 unit of money', the statement'1MF1bhgbhdjjckm96NJHGFGvbhVC sent 1 unit of money' appears. As seen in the example, the real identity of the person is safe and all his actions with the username can be easily followed. As a result, large companies and organizations are forced to act more responsibly in their account transactions.

3-Unchangeable (unable to be tampered): In the blockchain system, where all users can easily access existing data, the data is prevented from being changed by hackers. The data packet (hash pointer) of each block in the blockchain is the same as the previous one and carries the data of all previous blocks. Therefore, when a change is requested in the data on a block, the data of all blocks before that block will also need to be changed. This is not possible because the blockchain system is dynamic and new blocks are constantly added to the chain.

4-Using automated execution contract: The blockchain can be turned into smart contracts by writing code that stipulates the obligations that each party in the contract must fulfill and the conditions for the execution of the contract. When all the determination conditions are met, the blockchain system will automatically apply the contract terms. On the other hand, it has increased the efficiency of contract execution and, more importantly, ensured the effective implementation of the contract without the oversight of a strong third party.

5. Traceability, data tampering protection, security and reliability: Traceability means that records added to the blockchain are stored permanently and the information of users is linked to every transaction record on the blockchain. All transfer stages of the transaction object can be recorded and monitored. It makes the control of the transaction easier. Blockchain technology uses asymmetric and cryptographic principles to encrypt data. The powerful algorithm created by the consensus algorithm is used to defend against attacks and to guarantee the non-destructive modification and immutability of blockchain data. Blockchain technology provides significant benefits for the applied sector depending on the usage area. Blockchain technology has many benefits such as reducing transaction costs, accelerating transactions, and being very difficult to change data. In summary, Blockchain technology offers some opportunities:

- Low transaction costs due to not being intermediaries
- Falling prices as a result of greater market transparency
- A simple option for customers to become service/electricity providers
- Making transactions simpler (documents, contracts, payment)
- Greater transparency through decentralized data storage
- Flexible products (tariffs) and supplier switching
- Empowering consumers through independence from the central authority (direct energy purchases/sales)

2.5. Disadvantages of Blockchain's Technology

While blockchain technology has many advantages, the current operating system is still not perfect and carries many risks. These risks can be expressed as:

- *Loss of data*: If there is a problem with the storage of information, the possibility of a loss of business information can be a serious problem.

- *High transaction costs*: It is considered that these costs, especially in public blockchain systems, will affect the financial situation of businesses.

- *Possibility of not being accepted by the addresses*: For example; An electricity producer who wants to use this system may experience difficulties if the consumer vetoes the use of this system.

- *The vacuum of authority*: The absence of an authority to appeal in case of a dispute, and not knowing by whom the damages will be remedied, appear as a different problem.

- *Risk of fraud*: When an illegal method is used at any stage of the system, irreparable damages may occur.

- *Lack of experience*: One of the disadvantages is that the long-term outcomes are not clear at the moment.

- *Security risks*: It is natural for each person using the system to wish that there are no security-related vulnerabilities. Any attack that may occur in the system will endanger the security of the system [27].

2.6. Areas of usage of Blockchain Technology

Blockchain technology is a proprietary technology system created for peer-to-peer trading platforms that use a decentralized storage system to record all transaction data. A newer application is emerging that combines the application of blockchain with the mechanisms that allow transactions to be executed in a decentralized system. The first blockchain was developed in the financial industry to form the basis of the “Bitcoin” cryptocurrency. In addition, mechanisms called “Smart contracts” work on the basis of individually defined rules (quantity, quality, price characteristics) that allow autonomous matching of distributed providers and their potential customers. For example, smart contracts can be coded after the necessary prerequisites are met, and files can be stored by using data available to all users. In addition, by using the transparency feature of the blockchain system in government elections, the election results can be reached reliably. The blockchain system can

also be used for the Internet of Things (IoT), which is defined as the interconnection of different electrical devices via the Internet. In addition, the blockchain system is expected to be used in transactions such as crowdfunding, stock trading, protection of intellectual property, identity management and land registry. The most common usage of blockchain technology can be listed as cryptocurrencies, crowdfunding, identity management, banking, smart contracts, file storage, insurance, healthcare, supply chain and energy sector. Various usage areas of the blockchain system are summarized in Figure 2.12 below.

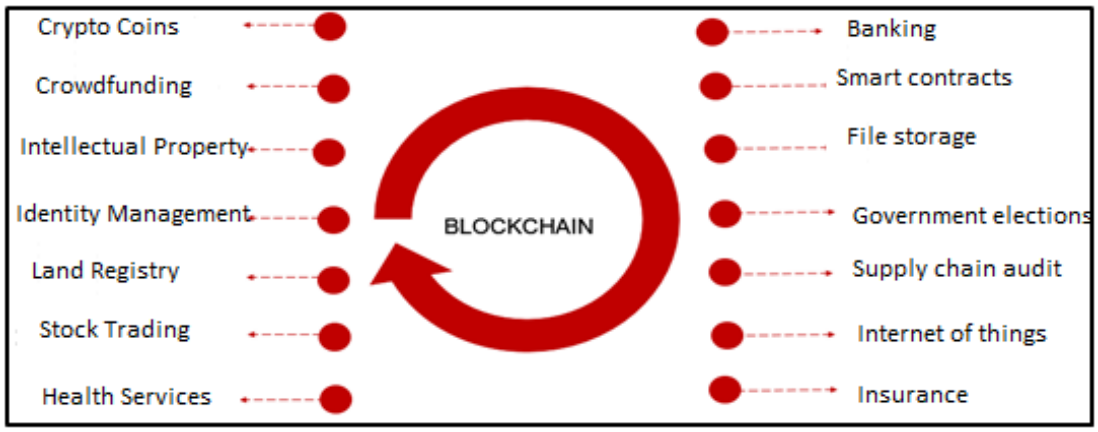

Figure 2.12: Various usage areas of the blockchain system (reproduced from [14]).

As seen in Figure 2.12, blockchain technology is applied in some areas such as the use of cryptocurrencies, smart contracts, health, energy sectors, and supply chain. With the development of technology, the possibility that these areas will increase is inevitable.

2.6.1. Future Application Areas of Blockchain

The following areas can be given as examples of current and possible future application areas of blockchain.

Technology: The technology sectors affected by the blockchain can be grouped as the following headings:

Cloud storage: This system, which operates in a centralized structure, is in a vulnerable position against the stored data. By switching to blockchain technology, which is a distributed structure, data loss can be prevented.

Internet of Things (IOT): High transaction speed and low cost are the benefits of using blockchain in the IoT. IBM Spotlighted blockchain and Hyundai Digital Asset Currency (HDAC) are blockchain-based IoT projects.

Power and energy management: The way of storage, distribution and production of energy will undergo a radical change with blockchain technology. In the central system in which intermediaries play an active role, the number of units that get a larger share of the pie is quite high. Thanks to blockchain technology, there will be no need for intermediaries, and as a result, there will be reductions in transaction costs. Conjoule based in Germany produces peer-to-peer energy transfer solutions by using blockchain infrastructure. Conjoule, funded by the Innogy Innovation Hub, reached a total of € 4.5 million in the first phase. The first phase of fundraising was closed, and Tokyo Electric Power Company (TEPCO) took a big step with this investment in the blockchain world where many energy companies also work.

Cyber security: Thanks to the blockchain, institutions can encrypt their data in a distributed way. In this way, the data can be protected against attacks that may come from outside.

Media: The media sector, which is a constantly growing sector, is not consumer or creative friendly due to the central authorities, which we can describe as 3rd parties that provide them an advantage and bring in. Thanks to the blockchain, it is considered that media contents can become more accessible to users with the elimination of high costs. We can group the media sectors affected by the blockchain as follows:

Advertising: Blockchain can change the advertising industry in two ways:

i. With the new blockchain-based browsers, it becomes possible for users to turn off ads and protect their privacy.

ii. By using the browser blockchain technology called Brave, it is possible to provide P2P interactions of users and advertising companies without intermediaries such as Facebook and Google.

Market assessment/foresight: Blockchain transformation can accelerate forecasting to a new level. The fact that blockchain stores large amounts of data demonstrates its usability with machine learning or artificial intelligence.

Game sector: Today the game sector is dominated by investing companies. Thanks to the blockchain, small game developers can bring their games to the world regardless of permission or fee issues. Blockchain and cryptocurrencies provide new ways to benefit from reward mechanisms through smart contracts. This decentralized technology also introduces the next generation of reward applications. Bounty, one of these new generation reward applications, is a reward given by completing a very special task. For example, people are rewarded for successful completion of tasks such as doing programming or just promoting a project. Bounty tasks range from simple social media promotions to high-level technical debugging. In summary, Bounty can be thought of as a reward for help or service.

Law and crimes: Blockchain maintains the integrity of data so it is a great platform to store all evidence. It can also be deployed without worry and adds a layer of security to the security application.

Transportation: It is evaluated that the transportation industry can be improved with blockchain-supported projects in terms of reducing transaction and administrative costs, low disputes, and improving overall transportation speed. The project of RedCab produces solutions with the software that tries to integrate the problems of the taxi industry and customers into the blockchain.

Government policy/governance: The purpose of the government wanting to use blockchain technology is to achieve governance rights, have a proper transparent voting system, ensure citizen rights, minimize fraud in the system, and improve the law and order decision-making process with blockchain solutions that can run smart contracts.

Travel industry: With the unique digital identities to be given to individuals on the blockchain, it will be easier for the government to track and manage them.

Health sector: Providing health services to citizens, which is one of the main duties of governments, can become more sustainable, reliable, scalable and traceable with blockchain.

Education: In online education services, the central authority, which is the third party between the service requester and the service provider, will be eliminated with the blockchain. Those who request the service will be able to get service at a cheaper price.

Human rights and donations/right to information: The right to information is a fundamental human right. Today, most people may have to wait days to get information about some subject, fulfill unnecessary bureaucracies and then get an answer. Blockchain can facilitate a convenient transaction for people with appropriate data management and access.

Contracts: Contracts exist to determine the terms of issues such as business agreements and payments between two parties and to ensure that the parties act following them. It is possible to examine contracts in three sub-categories;

Inheritance: Thanks to smart contracts, inheritance transactions can be moved to the blockchain platform. It is evaluated that inheritances can be digitally transferred to anyone they want after people die with smart contracts.

Legal contracts: With smart contracts, intellectual property rights can be protected against the risk of being stolen by others.

Property and land: Ownership of property and land can be secured and their prices determined by smart contracts.

Donations: Blockchain makes donations transparent. It also provides easy tracking to know where donation money is used [28].

Chapter 3

Blockchain Technology and Energy Sector

Blockchain technology has brought innovations to many fields. One of them is the energy sector. The blockchain-based payment system, which is used in the production and sale of energy, has brought payment, security and loyalty initiatives to the sector. According to the legislation in our country, producers cannot sell energy directly to the ultimate consumer without obtaining a license. If a blockchain-based payment infrastructure is used, payments between producers and between producers and consumers can be made without intermediaries, they can buy energy when it is cheap. They can use the energy they bought in the past even though they are no producer, and they can even sell them to someone else for a more expensive gain. By installing the payment system on smart meters, its prevalence will be increased. The developed payment system can be used in scenarios such as selling excess energy to a neighbor who produces electricity at home or selling with charging vending machines integrated with renewable energy sources. It can be designed in such a way that the user can take her energy and pay with the crypto money s/he has bought before and earn points from the system depending on the amount of payment and then convert her/his points back into energy.

With this system, the problems of energy producers such as loss and leakage cost, invoicing, a credit-debt relationship will be arranged for both parties and the problems experienced in these matters will be eliminated. It is predicted that the capacity shortage will increase with the increase in the number of electric vehicles. Investments to overcome this problem will bring an economic burden to our country. The projects which will be realized without the need to invest in capacity provide the economic profit and contribute to the protection of the environment by turning to renewable energy sources [29].

Blockchain technology has been researched and accepted in solving existing problems in different industries. The possibilities offered by this technology are not ignored in the energy sector, which is the biggest contributor to the global economy. Technology companies, governments and all their affiliated institutions come together and collaborate to create a blockchain-based platform to solve existing problems in the energy sector. Blockchain technology is predicted to play an important role in the operation and trade of both renewable and fossil fuels. Figure 3.13 shows the use of blockchain technology according to the problems that occur in different areas of the energy sector.

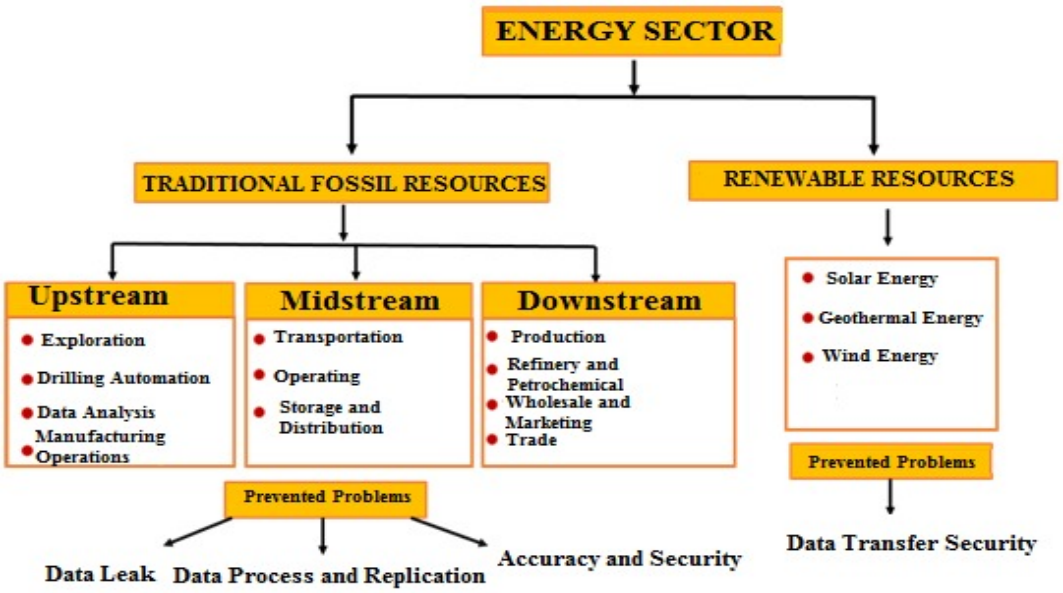

Figure 3.13: Applications of the blockchain system in the energy sector and its use according to the problems

As it is seen in Figure 3.13, Solution proposals to be brought by the blockchain system are seen on both the traditional and renewable energy sides of the energy sector. It is predicted that the blockchain system will provide a great impetus to the energy sector, especially in the field of data security of the oil and gas industry.

Although the importance of renewable energy sources is increasing day by day, oil and natural gas, among the traditional energy sources, continue to maintain their importance (Figure 3.14). This type of energy constitutes the majority of energy consumption. It is predicted that it will continue to maintain its effective position in the markets for approximately 15-25 years.

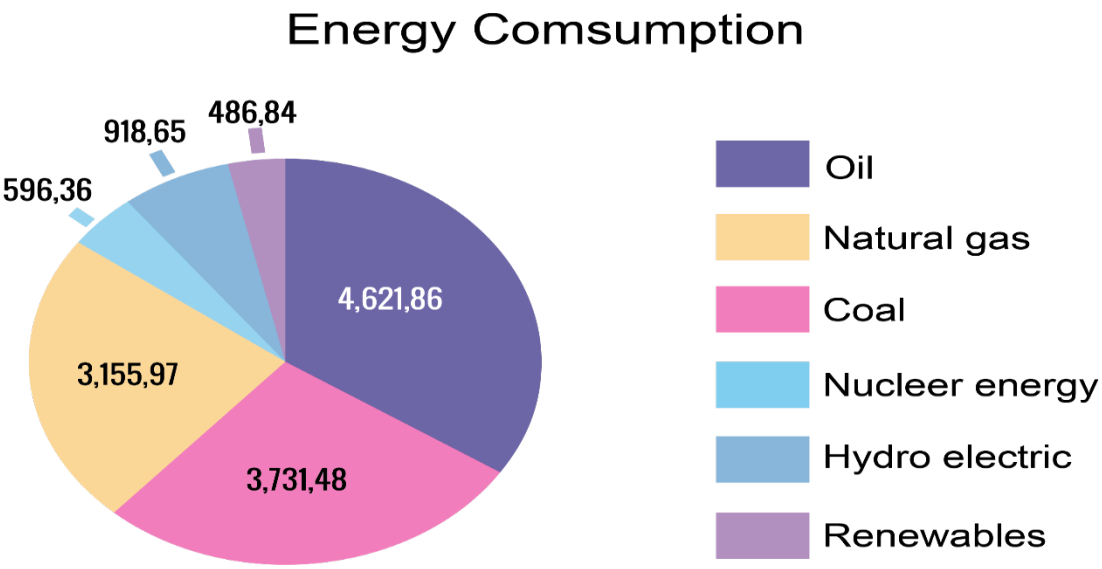

Figure 3.14: Energy consumption in 2017(unit millions of tonnes equivalent) (reproduced from [22]).

Parallel to its active role mentioned above, new technologies in the field of oil and natural gas also show a great development. It is observed that the oil and natural gas industry is gradually developing towards intellectualization, digitalization and automation. However, the management mode is relatively old and has the characteristics of low efficiency, high cost, long term and high risk. The oil and gas industry can be divided into three segments based on market segmentation: upstream, midstream and downstream.

Upstream refers to the exploration for and extraction stages in the oil and gas industry. It is responsible for managing an exploration, development or production operation. The key players making up the upstream are the oil and gas companies that have a say in this area. A lot of data is collected regarding upstream. The correct evaluation of these data is of great importance. Blockchain technology is a concept that can help companies in these matters.

Midstream refers to the industry segments involved in the storage and transportation of resources. It also includes the administration of transport networks and important regulations regarding transport. The midstream oil and gas segment can benefit from disaster mitigation and infrastructure maintenance. Detailed regulations and asset concentration require oil and gas companies to focus on risk reduction. As a result, these firms can uniquely benefit from sharing knowledge with other firms in the industry. Blockchain technology is very important for stakeholders to be informed and follow the flow.

Downstream refers to storage and sales. It refers to companies that convert resources into multiple end products or sell products from the producer to the end consumer. In addition, the downstream includes the management of dozens of different oils and derivatives. These products are for different customers, have different environmental regulations, and require various shipping methods. Blockchain-enabled supply chains optimize large-scale and multi-product coordination. The ability of a blockchain technology platform to record and track data can prevent large amounts of wasted money.

Moreover, a platform using smart legal contracts can replace the time, energy and money that all relevant energy companies currently need. A distributed ledger can help evaluate the data required for all phases of oil and gas production. This will prevent wastage by ensuring that everything is planned correctly, and will save a tremendous amount of time and money [30].

According to [22], the solutions that the blockchain system can bring to some problems are as follows;

Upstream:

-*Equipment monitoring issues*: The number of devices is excessively large. Asset integrity management is not perfect. As a result, it is faced with human errors and large audit penalties.

- *Data breaches*: Wrong data will inevitably lead to wrong decisions as a result of situations such as the location where the data is generated is different or the data is not stored well.

Midstream:

Data processing and multiplication: As a result of recurring third-party transactions or recurring contracts between different parties, there may be an increase in operating costs and the number of erroneous and delayed transactions.

Downstream:

Integration and security: Since closed networks are vulnerable to external attacks, they result in fraud, loss of trust, and increased verification costs, etc.

The main problems of this sector are stated below:

- Density of bureaucracy causes cost increase and loss of time.

- The oil and gas industry features multilateral investment and cooperation, and the risks of fraud, error and inefficiency in transactions are relatively high.

- The oil and gas trade has relatively high third-party management costs, changing important data takes a long time.

- Information in the archive is vulnerable to external attacks.

Considering the mentioned problems, we come across the necessity of making some updates in this sector. Just like people, businesses can be hesitant to use a new

technology. For this reason, nowadays, businesses follow the way of observing how other businesses use this technology and getting some results from this situation.

To be a pioneer in the sector, oil giant BP has officially started and continues to cooperate with the Canadian blockchain startup BTL Group, the world's eighth-largest energy company[31, 32]. Guy Halford-Thompson, co-founder and CEO of BTL Group, stated that they have demonstrated the reduction in risk and cost savings achieved, and now they have the opportunity to present the first successful blockchain-based application to the energy market. The use of such technologies can help streamline office processes, reduce risk, contribute to better protection against cyber threats and ultimately contribute to cost savings. He also stated that more engineering and organizational efforts are needed to achieve these results.

3.1. Key Application Areas for Blockchain in the Energy Sector

Many application areas can annually provide billions of dollars of global value through greater automation, direct transaction, revenue growth and cost reductions. Investors should consider application areas that offer the promise of value creation in the energy sector, such as:

Systems of certificates of origin for renewable-energy markets: Practices that certify that the energy has been generated from renewable energy sources certify the qualifications of each unit of renewable energy, and tracks ownership transfers between market participants concerning clean energy.

Service billing systems: It is a system where the records of payments and other transactions made by users are kept.

Request response programs: Consolidation associated with participation in a specific request-response event, real-time measurement and verification (M&V), and any application that performs the settlement and trade.

Electric vehicle charging networks: Any application that manages customers, vehicles and charging infrastructure using cryptographic identities

Transactional energy systems: Any market design where electrical grids are balanced and controlled through intelligent software agents that perform grid communication and control functions for physical assets by responding to temporary and local price signals.

For example, Share & Charge is a decentralized protocol for electric vehicle (EV) charging, transactions, and data sharing and was developed by MotionWerk to promote EV use. The protocol facilitates access to EV charging stations, participation in demand response events and other grid services, and proves that the electricity used to charge EVs comes from renewable generation. This application helps align split EV charging point markets and grid service offerings to improve the experience of existing electric vehicle owners and to increase potential owners' interest of electric vehicles[33].

Invoicing: Automatic invoicing is essential for both producers and consumers. The payment diversity potential of blockchain technology can fulfill this.

Sales and marketing: Sales practices may vary according to consumers' energy profile, personal preferences and environmental concerns. Blockchains, along with artificial intelligence (AI) techniques such as machine learning (ML), can detect the consumption pattern and determine which products are preferred by whom.

Trade and markets: Blockchain-powered distributed trading platforms can regulate market operations such as wholesale market management, commodity trading and risk management.

Automation: Blockchains can regulate the control of distributed energy systems and microgrids. Peer-to-peer energy trading or the adoption of local energy markets provided by distributed platforms can significantly increase the self-production and

consumption of energy, resulting in changes in meter activity, revenue and expenditure.

Smart grid applications and data transfer: Blockchains can potentially be used for smart device communication, data transfer or storage. Smart devices in the smart grid include smart meters, advanced sensors, network monitoring equipment, control and energy management systems, but also smart home energy controllers and building monitoring systems. Smart grid applications can benefit more from the data standardization provided by blockchain technology, in addition to providing secure data transfer.

Network management: Blockchains can help manage distributed networks. Blockchains can generate changes in revenues and expenses for network usage.

Security and identity management: Transaction protection and security can benefit from cryptographic techniques Blockchain can protect privacy, data privacy and identity management.

Sharing of resources: Blockchain could offer charging solutions to share resources among multiple users, such as EV charging infrastructure, data or shared centralized community storage.

Competition: Smart contracts could potentially replace traditional energy suppliers and save time. Increased market activity can increase competition and potentially lower energy prices.

Transparency: Immutable records and transparent processes can significantly improve auditing and compliance while ensuring accountability [34].

It is expected that the use of blockchain technology in the energy sector increases by 45% by 2025. The main reasons for the growth of this technology in the energy sector are; It reduces the operating cost and the process is carried out faster.

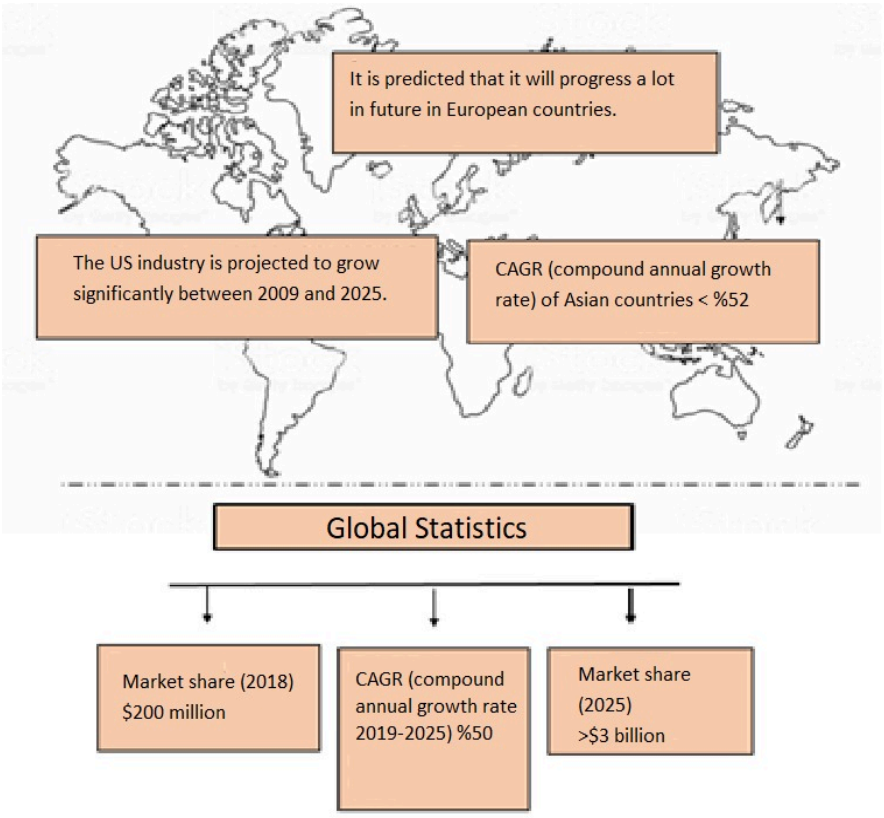

Figure 3.15: Statistical data of the blockchain system in the energy market on a global basis [35].

As it is seen in the figure above, it is estimated that blockchain technology will occupy a large area of market shares around the world. Blockchain technology, which operates in many sectors all over the world, is newer in the energy sector compared to other sectors. It is expected that this situation will change significantly in the coming period and many enterprises in the energy sector are expected to devote time and cost to this technology.

Today, in addition to fossil resources, the use of renewable energies is increasing day by day [19]. One of the increasing usage areas is the electrical energy produced from these sources. In terms of the dynamics of the energy market, the search for solutions continues to take the existing traditional structure to the next level. The distribution of electricity from the producer to the consumer without an intermediary is at the head of the search for solutions, With this technology, it is aimed to meet the charging needs of electric vehicles by individual users instead of stations. The issue

of how the existing structure will adapt to the new system with the implementation of alternative solutions continues to be investigated. With the integration of blockchain technology, it is necessary to make appropriate legislative arrangements for this system [36]. Figure 3.16 shows the comparison of traditional process and blockchain system applications in the electricity market.

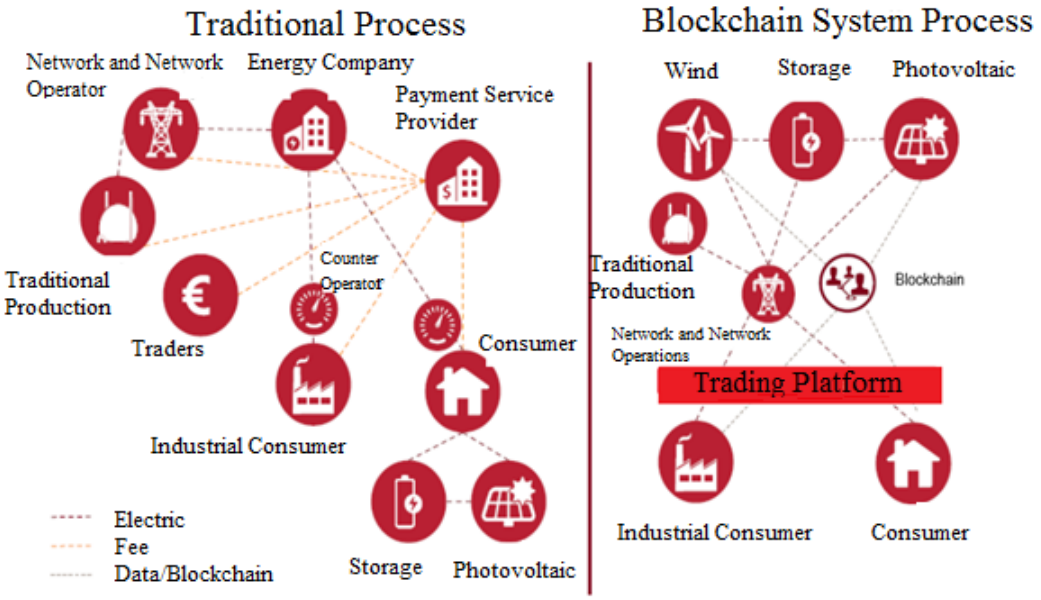

Figure 3.16: Comparison of traditional system and Blockchain system [14].

As it is expressed in Figure 3.16, while transactions are connected to a central service provider in the traditional system, there is P2P communication in the blockchain system due to the use of distributed ledger technology. In this way, the use of a distributed ledger technology in a system consisting of many elements saves both time and cost.

Figure 3.17 presents the network map of organizations showing blockchain-based activities in the energy sector.

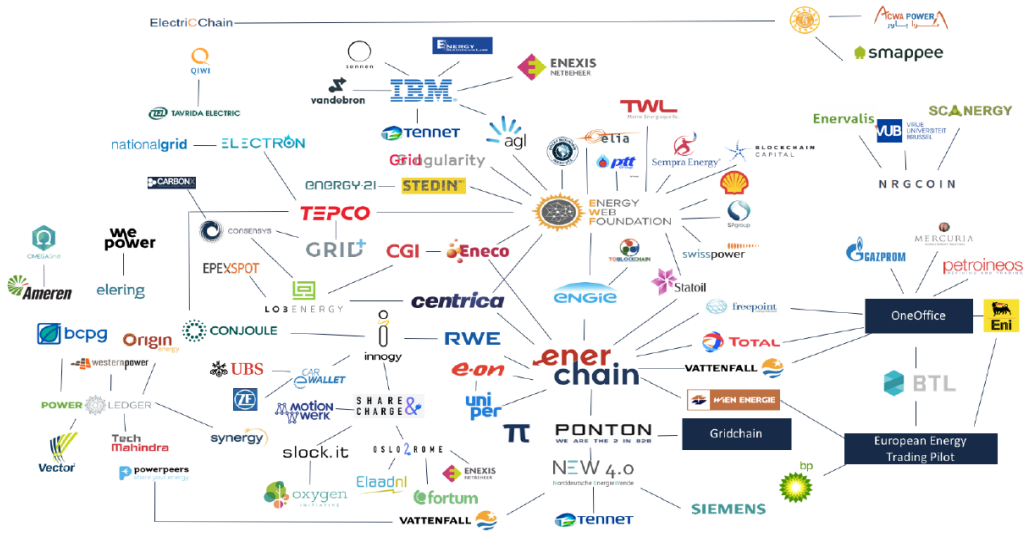

Figure 3.17:Network map showing blockchain-based activities in the energy sector [26].

When Figure 3.17 is examined, it is observed that many enterprises, especially giant companies such as BP and Shell, have started to use the blockchain-based system. It is considered that in the coming years, with the decision of many enterprises to use the blockchain infrastructure, they will sign contracts with infrastructure provider companies and this network map will expand further.

3.2. Blockchain in the Oil and Gas Industry

According to the studies, the benefits of blockchain technology to the oil and natural gas industry can be grouped under the following headings:

- Commerce,
- Impact on the decision-making process,
- Controllability
- Cyber security.

Detailed explanations of these 4 elements and the chain of the oil and natural gas industry are given in Figure 3.18.

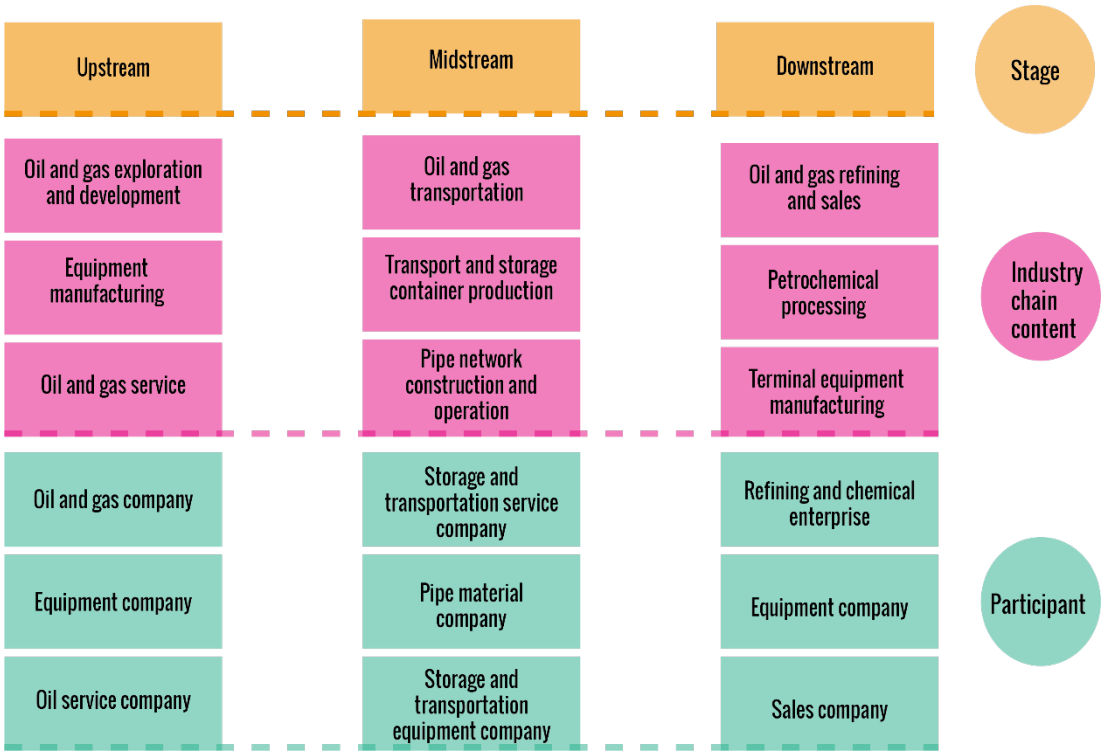

Figure 3.18: Oil and gas industry chain (reproduced from, [22])

As it can be seen in Figure-19, the components that make up the upstream, middle and downstream sections are revealed. It will be explained what advantages the blockchain technology will bring about upstream, which expresses the stages of exploration and extraction in the oil and gas industry, midstream, which expresses the industry segments related to the storage and transportation of resources after extraction, and finally downstream, which refers to the storage and sales section.

3.2.1 Commerce of Oil and Gas

According to Ernst & Young's 'Global oil and gas transactions review 2017', total annual oil and gas transactions were $343.5 billion [37]. The report also performed statistics and analysis based on upstream, midstream and downstream trading volume. Blockchain technology can be applied through smart contracts in the oil and natural gas industry, which has many dynamics such as oil exploration, transportation and distribution. These phases include many transactions and contracts and this results in a large amount of consensus and follow-up studies.

3.2.1.1 Smart Contract

A smart contract is a type of contract that records the binding clauses in a contract with machine language and can be cited among its most important element in Ethereum. [38]. The smart contract can receive transaction requests and events from the outside and it can create new processes and events by pre-triggering the running code logic. The results of the smart contract can be updated for the state of the ledger on the Ethereum network and cannot be forged or tampered with after these changes are approved. The fact that any element other than the parties to the contract is not involved makes the implementation of the smart contract attractive. It is expected that this contract will accelerate the sector due to its features such as shortening the process, making it more applicable and providing a cost-effective structure. In order to prevent time and cost loss, it is also important to reveal the security principles of the contract.

3.2.1.2 Process

Oil prices are constantly increasing nowadays. The industry is dealing with demands by many authorities to increase productivity and reduce costs. Blockchain technology can be considered as an effective method to solve the difficulties that the industry struggles with such as mistakes and fraud [37].

The parties to the contract can easily see the transactions made. This can also ensure accountability, thus increasing the success rate of the transaction. In addition, both parties to the transaction can see the specific situation at each stage in the transaction process to further control the overall situation [39,40].

In the field of trade, a long process is observed from the producer to the end-user. The fact that the process is long and complex is the main purpose of the implementation of the blockchain system. Countries attach great importance to foreign trade as well as to domestic trade. The quantities sold to other countries and the frequency of transactions in the sector are very high. With the implementation of

the blockchain system in the payments to be made and in the follow-up of this long process, intermediaries can be eliminated, and a great saving in time and cost can be achieved.

3.2.2 Impact on the Decision-Making Process

The review of blockchain technology under this title can be grouped under two headings: decision-making process and management:

3.2.2.1 Decision-Making

Blockchain can also make a critical contribution to the decision-making process. There are many design-related issues in oil and gas exploration and development, such as 3D data scanning of underground reservoirs, oil and gas development programs, and the design and maintenance of oil and gas-related devices. In the current situation, the time from feasibility study to implementation usually takes months or years. In order to increase the efficiency of blockchain technology, the evaluation of data is of great importance. When a business needs to decide on something, it needs all the data. Recorded data can be independent of each other, so it is difficult to track and process. Bringing together and interpreting data of different structures can often be difficult. Since the processing of data with Blockchain technology will be provided by a common algorithm, the process of interpreting the data and decision-making can be facilitated. In the decision-making process, the opinions and votes of business managers are of great importance. As a result of a vote to be made through a smart contract, the element of transparency can be easily observed, which can increase trust in the business [41].

3.2.2.2 Management

The main function of the blockchain is to simplify the process and make the management functional. As we all know, the industry has many dynamics. Among them, pipelines are one of the most prominent issues. The allocation and management of the pipeline network are one of the most challenging issues for

businesses. Blockchain technology can be used in this management process. If production and consumption data are followed through the system, the use of resources can be made more effective. At the same time, the security of the line is also ensured.

3.2.3 Controllability

The benefits of blockchain technology to the oil and natural gas industry include ensuring the auditability of the system. The term controllability can be examined under the headings of monitoring and compliance.

3.2.3.1 Monitoring

Oil and gas-related products are extracted, transported and sold by many elements in the sector. If any lack of communication between these elements occurs, the whole system is adversely affected [42]. For this reason, the audit activity provides control of the equipment used throughout its life cycle. It provides transparent control of all stages and paves the way for a cost-effective process. In matters such as the extraction, transportation, distribution and sale of the above-mentioned products, we come across stages such as sharing the databases of each element, allowing them to be audited, encrypting and verifying the shared information.

3.2.3.2 Compliance

Blockchain can also resolve some bidding or management issues during oil and gas exploration and development. Examples include the issue of invalid tender, the contract negligence liability in the project proposal, and the legal liability of refusing to sign the contract after winning the tender.

3.2.4 Cyber Security

Since businesses in the sector contain a lot of critical data and data density, the sector is vulnerable to cyber attacks that may come from outside. Blockchain systems can

be used to protect important data against such attacks. With distributed structure and encryption, the risk of attack can be minimized.

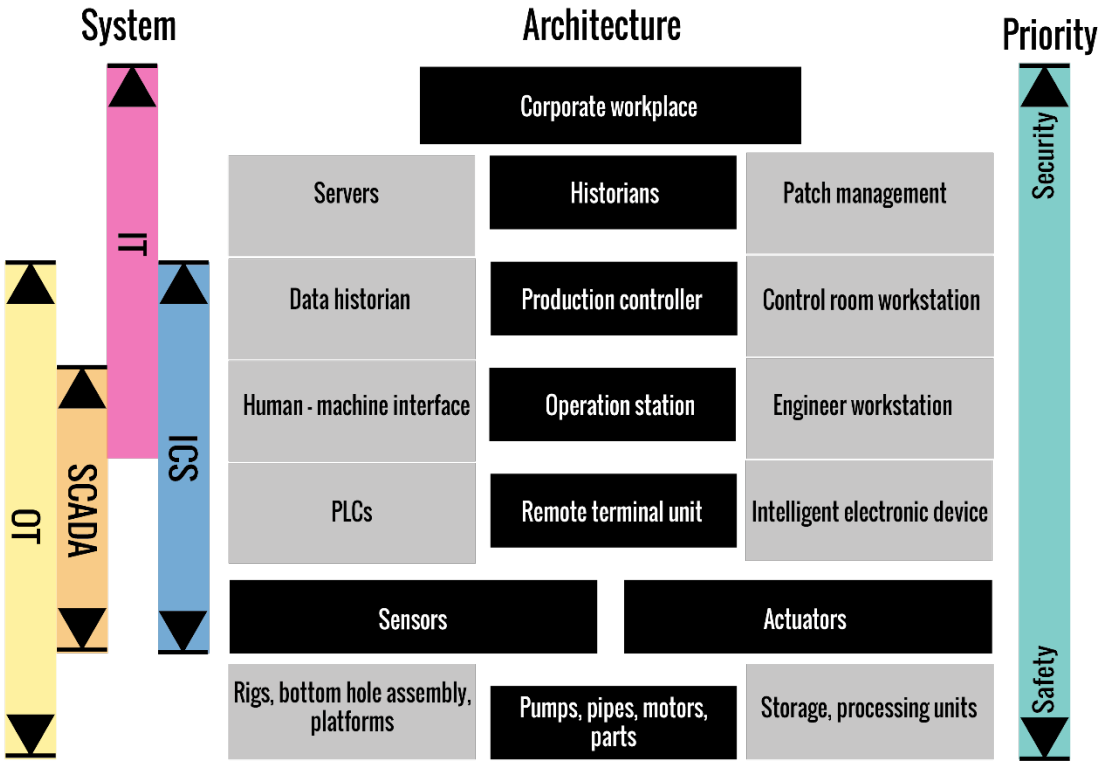

Figure 3.19: Oil and natural gas business structure (reproduced from, [22])

As it is seen in Figure 3.19, it is expressed what kind of elements especially information technologies and operational technologies contain in the security of the system. For a cyber attack, oil and gas companies have many vulnerable breakthroughs, such as complex operating system and production processes, the little intersection of information technology and operating technology, real-time system latency caused by a firewall, irregular updating of system security. If blockchain technology is used to store important data in a distributed manner, the risk of network attacks can be effectively reduced.

3.3. Application of Blockchain Technology in the Oil and Gas Industry

Today, the application of blockchain technology in the oil and gas industry is at the initial stage. Two well-known related blockchain projects are: Vakt and Komgo SA [43], Vakt is a blockchain-based commodity trading postprocessing company. On November 29, 2018, it announced the world's first enterprise-level blockchain platform for the crude oil industry. Its first users include BP, Equinor, Shell, Gunvor, and Mercuria, and will launch larger products in January 2019. Their goal is to increase speed and security, which benefits everyone in the supply chain from market participants to customers. Vakt uses J.P.Morgan's Quorum blockchain technology. [44]. Another important project, Komgo SA, is a blockchain platform for commodity trading that is supported by commodity supply contracts. The Komgo platform significantly increases transparency, while its "privacy by design" architecture allows for private peer-to-peer transactions. This design pattern radically improves trust and accelerates access to trade finance by reducing operational procedures and reducing the risks of failure and fraud across the industry. Authorized parties include banks, commodity traders, energy companies, audit firms and the broader ecosystem of contributors. On August 16, 2019, ING successfully completed its first commodity transaction in Komga. The Geneva branch signed an oil trade agreement with a letter of credit issued on behalf of Mercuria Energy Trading SA.

3.3.1 Use Case of Blockchain Technology in the Oil and Gas Industry

It is indispensable that issues such as the application status, advantages, disadvantages, threats and future status of blockchain technology in the industry should be addressed. Table 3.2 shows the most prominent oil and natural gas blockchain projects in the world, and Figure 3.20 shows the statistics on the oil and natural gas blockchain projects of the leading companies around the world.

Table 3.2. The leading projects in the world [22]

Continent	Location	Gas/Oil	Stage	Name/Company	Remark
Asia	Xiamen, China	Oil	Test	Sinochem Group	Simulated gasoline export from Quanzhou to Singapore
Asia	Abu Dhabi	Oil and gas	Test	Adnoc and IBM	Oil and gas production automation
North America	Houston	Gas	Test	S&P Global Platts	Platform for confirming transactions, reporting prices
Europe	London	Oil	Pre-Launch	Vakt	Platform to cut post-trade costs
Europe	London	Gas	Pre-Launch	OneOffice (BTL)	Platform to cut post-trade costs
Europe	Hamburg	Gas	Pre-Launch	Enerchain	Platform for P2P wholesale trading
Asia	Fujairah	Oil	Live	FOIZ, S&P Global Platts	Oil terminal stock levels reporting
Africa		Oil	Test	Mercuria, ING, SocGen	Digital documents used for cargo traded three times on way to China
South America	Chile	Oil and gas	Live	Energia Abierta	Regulator tracking national energy data
Europe	Britain, Italy, Austria	Oil and gas	Live	Interbit	Oil and gas trading
North America	America	Oil and gas	Live	PetroBLOQ	Oil and gas supply chain management
Europe	Switzerland		Live	Komgo SA	Trading platform

When Table 3.2 is examined, there are continents, countries and company names where the world's leading blockchain projects are located. The world's leading companies such as Sinochem Group, IBM, Vakt, KomgoSA, Mercuria, ING carry out blockchain projects related to issues such as providing automation in the oil and gas industry, confirming transactions, reporting prices, reducing post-trade costs, peer-to-peer wholesale trading, oil and gas supply management, oil terminal stock levels reporting, etc.

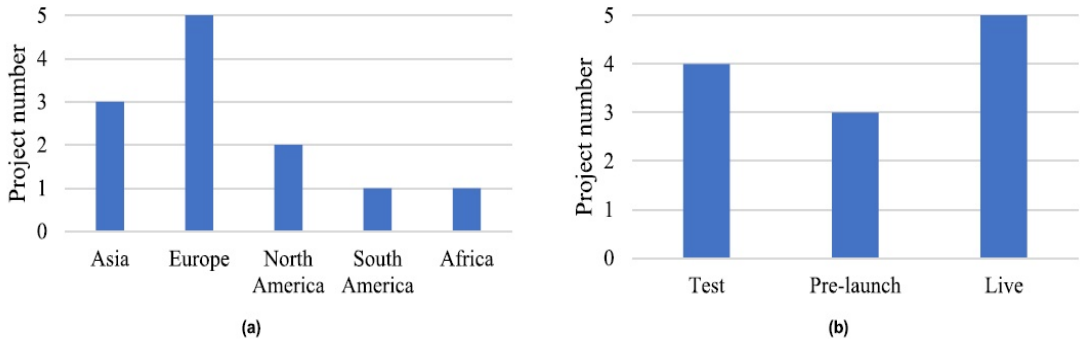

Figure 3.20: Statistics related to major blockchain projects. (a) By region. (b) By status (reproduced from [22]).

As it is seen in Figure 3.20, when we examine the statistics of the produced projects, Europe comes first. Europe is followed by Asia, North America, South America and Africa. Figure 3.20 resumes the status of these projects by the region and status. Looking at the last 5 years, it is noteworthy that blockchain projects have been started or are in the testing phase in the sector. While there are more blockchain projects in other sectors, especially in the use of cryptocurrencies, it can be stated that the energy sector has just transitioned to this technology. Many energy companies have started to devote time and money to this technology. Among them, BP and Shell are pioneers in blockchain application technology in the oil and gas industry. Sinochem Group successfully completed China's first blockchain crude oil import trade pilot project from the Middle East to China [45] at the end of 2017.

The following information is summarized from the statistical records of the participants in the oil and gas industry in the global blockchain survey:

(1) Close to 75% of respondents think that blockchain technology will make a big change in the industry;

(2) 60% of respondents think that blockchain is a cryptocurrency platform like Bitcoin and will only be used for monetary matters;

(3) In terms of investment in blockchain technology, only close to 10% of respondents in the oil and gas industry have invested more than $10 million. By contrast, close to 40% of automation respondents have invested more than $10 million in their organization;

(4) Only 15% of organizations in the industry implement blockchain in their businesses, while 85% only have knowledge of the system or use it for testing purposes in their business.

Based on the answers of the participants, it is observed that there are hesitations about the use of blockchain technology by the sector, and the budget allocated to this technology is limited.

3.4 Misunderstandings about Blockchain Technology

1- Blockchain is a distributed ledger technology: Blockchain is a type of distributed ledger technology and not all decentralized technologies use the blockchain

2- Blockchain is Bitcoin: Bitcoin is a type of cryptocurrency and an implementation of the blockchain.

3- It is absolutely impossible to change the blockchain: It is certainly not immutable, but the cost of changing is very high.

4- Smart contracts are legally binding: Without a separate contract agreement, smart contracts are legally binding.

5- Blockchain is the best database today: Blockchains are not necessarily better than traditional databases.

6- Blockchain is absolutely secure: Although blockchain is based on encryption standards, its method of ensuring confidentiality is completely outside of any blockchain standard and implementations.

Based on the above, it is considered that the blockchain will bring many advantages to the industry due to its distributed structure and transparency [46].

On the other hand, the probability of encountering some problems is naturally high when a new technology is first applied.

3.5 Opportunities of Blockchain Technology

Low transaction costs: Eliminated the involvement of intermediaries

Decrease in commodity prices: there was a decrease in transaction costs.

Convenient resource transfer: Customers will be more suitable to become suppliers and sell excess resources.

Convenient transaction: many documents, contracts and payments are simplified.

High transparency: Decentralized data storage and blockchain tracking

Standardized language: Data sharing is fast and convenient to use. It can provide standardized language, securely exchange information, and facilitate infrastructure sharing.

Asset integrity management: Data is almost impossible to change. It can be used to track assets such as oil and gas production equipment and pipelines.

3.6 Challenges to be Encountered

Way of thinking: Actors in the oil and gas industry do not have detailed knowledge of blockchain. For this reason, they apply the wait-and-see strategy and try to observe the status of those who implement this system and the functioning of the system.

Adaptation to the new market model: The launch of blockchain will change the way the oil and gas industry works and even change the approach of other related industries, it will take some time to adapt and coordinate.

Management: The current management of the oil and gas industry is still traditional. Blockchain technology currently seems difficult to adapt to the current governance environment.

Technology and security: Since the implementation of blockchain technology in the oil and gas industry is still in its infancy, there will be many technical and data security issues.

Specific performance: High-frequency business needs are difficult to meet; Consent-based algorithms consume a lot of energy; lack of relevant development, integration and maintenance systems; privacy protection, smart contract loopholes, and other security issues may also arise.

Legislation: There is no legal or regulatory framework yet.

Data quality: Blockchain cannot guarantee data quality, it can only guarantee the accuracy of the data.

Cost: If blockchain technology is adopted, it will include many management systems and databases maturely implemented in the oil and gas industry. Change costs a lot.

Professionalism: there are not many professionals in overall setting, especially in blockchain applications for the oil and gas industry.

Chapter 4

Inferences and Possible Scenarios about Blockchain System in the Energy Industry

It is foreseen that blockchain technology will be used in many sub-branches of the energy sector such as electricity, oil and natural gas, and will provide many benefits. Blockchain technology is expected to play a crucial role in energy trading, supply chain optimization, management, chain of custody, data security and regulatory compliance.

Blockchain technology has brought innovations to many fields. One of them is the energy sector. The blockchain-based payment system, which will be used in the production and sale of energy, can provide an expansion of intermediary payment, security and loyalty to the sector. According to the legislation in our country, producers cannot sell energy directly to the end consumer without obtaining a license. If the blockchain-based payment infrastructure is used, inter-producer, producer-consumer payments can be made without intermediaries, it can be purchased when the energy is cheap, it will be used the energy purchased in the past even if there is no producer and incomes will be earned by selling energy to someone. By installing the payment system on smart meters, its prevalence will be increased. The developed payment system can be used in scenarios such as selling excess energy to a neighbor who produces electricity at home or selling with charging vending machines integrated with renewable energy sources.

Blockchain could potentially be used for smart devices communication, data storage and transmission. Smart devices in the smart grid contain network monitoring equipment, smart meters, advanced sensors, control and energy management systems, as well as building control systems and energy controllers of smart houses. Besides ensuring secure data transfer, smart grid applications may provide benefit more from the data standardization offered by blockchain technology.

Considering scenarios such as charging stations and electricity sales from home to home, which will become widespread in the near future, a payment system that works on the blockchain platform can be built. In addition, with the system to be developed, it is aimed to prevent security weaknesses in the billing, production and consumption balance in the energy sector, since the data on the payment system is kept with the blockchain infrastructure. And also, it is considered to build a modular blockchain infrastructure due to its applicability on smart meters. As a second form of use, both vehicle charging stations and charging stations to be placed in front of individual residences will directly deliver the electricity produced in the solar panels to the users. Currently, due to the legislation in Turkey, it is not possible to sell electricity directly to consumers without licensing. A solution to this problem will be found with a system to be developed. Buyers will also be able to compare sales prices through the system. By logging into the system, users will be able to pay by transferring virtual money from their digital wallets in return for the electricity they receive. While doing this, a secure payment and loyalty system will be created for the energy sector by using the encryption algorithms that are at the base of the blockchain. Application to the energy sector by developing a system payment based on customer loyalty and blockchain [29].

4.1 Using Smart Meters with Blockchain Infrastructure

The latest technologies bring many innovation to daily life. Smart meters, one of them, may improve a residence's quality of life by giving transparent information about the consumption of energy. Unlike traditional meters, which simply track and

manually monitor the total electricity consumption during a certain period, smart meters are fitted with a digital data transmission instrument that permits consumers and utilities to produce electricity and consumption.

These new technologies rigged with decentralized transaction technologies like blockchain enable consumers to build a technological foundation for peer-to-peer marketplace and transcend the hierarchical relationship with intermediaries like utilities. On the other hand, technical devices can monitor and record valuable information about the interests and habits of citizens. Hackers can abuse reaching to sensitive information to perform penal offences such as tricking bills and accounts or claiming ransom.

Inadequate security protocols organizing the communication between utilities, household appliances, smart meters and their exposure to hacker attacks is a scenario that can be encountered. For this reason, the present system encourages utilities to concentrate the short-term cost savings instead of long-term investment in security.

Governments, containing regional governments, should create organizational structures that expedite the process of founding security guidelines by taking into account lessons learned from other sectors like mobile and banking. As device manufacturers, smart meter operators and power companies should pay more attention to security issues.

The smart meter has some critical access points and cannot be secure for various reasons. If the smart meter encounters an attack and loses control, it can access and misuse the consumer data. A type of invoice fraud can be committed by changing the invoice amount. On the public services side, the smart meter can tend to be an access point to a public organization's special network, and hackers can correspond their potentially critic assets. If it takes control of more than one point simultaneously, the supply balance and demand in the electricity grid can be seriously compromised.

The benefit of the blockchain system regarding the above-mentioned problems is that the network and protocol itself already have a safety system.

For example, it can have notifications about energy consumption, forward it to the major network and sign it with the personal keys. The utility is able to sure that it's put signature to this device because it's not nearly possible for the key to be used anywhere else. When we consider the smart meter revolution, it is significant that smart meters securely contain personal keys so they can be in touch with the outside world.

Smart meters will sooner or later become an important part of both smart cities and each household that procure a local or central electricity grid. In a company with the continuous technical improvements, they will allow consumers to prefer flexible tariff systems, save energy and attend actively to the electricity system.

The existing security systems of smart meters are not sufficient, especially the communication protocols and utility between smart meters and home appliances expose them to the risk of a hacker attack.

The first step is to develop an incentive system that addresses appropriate security requirements and obligations for both smart meter and utility manufacturers.

As a result, technical and digital innovation will promote in making smart meter infrastructure more resilient and sophisticated but should be accompanied by the right institutional and regulatory framework and legislation [47].

4.2 Inferences about Oil and Gas Industry and a Case Study

Blockchain technology has great potential in the oil and gas industry.

Crude oil is the most important fossil resource due to its trading product and variable price, which plays an active role in the energy market. Therefore, the blockchain system must provide convenience in the oil industry. Blockchain technology can make the oil and gas industry, which is among the areas open to innovation, more efficient by replacing traditional methods [39]. Due to the lack of widespread digitalization in the oil and natural gas industry, various inconsistencies may occur in

invoice generation and shipment routing in the industry. In order to reduce or prevent the negativities in this sector, some large companies have announced that they have started to digitize various oilfield-related services and use blockchain technology. In addition, it is thought that the cost can be reduced as there is no need for an intermediary with blockchain technology to be used in the oil and natural gas industry [35].

With the rapid development of technology, there are some innovations in the oil and natural gas sector such as the internet of things, automation, artificial intelligence, digital change etc. It is thought that a transformation is necessary to use innovations in this sector.

The energy system uses the traditional system in which all data are collected in a single center and it is also continued in the oil and natural gas industry. In this centralized system, often data centers are controlled by third-party vendors, so blockchain technology seems to be a suitable alternative for data control. Linking various engineering analyzes such as updating data, making it reliable, well analysis and identification with data blocks can be performed more easily [48,49]. For example, in a well analysis, the historical data that will be stored in the blockchain database will contribute to new projects, the determination of the region to be studied and the decision-making process.

Blockchain technology can increase operational efficiency, save time and thus speed up data exchange in the drilling works of the oil industry. The use of blockchain technology in engineering data management can help the system. As an example, artificial lift methods on an old well can be shown. When the methods and efficiencies used in an old well are uploaded to a blockchain database, it can contribute to the petroleum engineer in terms of creating and implementing the strategy correctly. Finally, the changes to be made in the drilling automation software of the manufacturers and the data that will occur in the blockchains can be independently verified in the system, instantly updated and also submitted for the approval of the users. Thus, creating a reliable stand-alone platform for drilling automation will ensure reliability throughout the system.

In today's world, it is essential to design and offer a useful platform to meet the application and security needs in the oil and gas industry. it covers the applications of the traditional system, local server platforms and cloud computing for storage and network resources, and all digital data processes, whether at the drilling site or not. By using this system, the operating company can share confidential technical data about the well with the service provider and government agencies. However, this system can be vulnerable to hacker attacks due to a single attack, several attacks at the same time, and configuration errors in any of the system components. At this point, it is recommended to develop a computer system that can communicate with blockchain technology in order to protect privacy and ensure reliable data sharing.

As the use of digital innovations such as artificial intelligence, cloud computing, automation and the Internet of Things (IoT) increases, the application of these emerging systems to the drilling site infrastructure can be improved. Distributed ledger technology, also known as a private blockchain, could form the basis of this new infrastructure. It can deliver performance and functionality with a private blockchain platform, scale and interoperate with different client systems. It can also provide convenience for data, systems, and users to ensure compliance audits, security, and business continuity.

As a case study, UAE-based oil giant Abu Dhabi National Oil Company (ADNOC) has started to use blockchain technology for its oil and gas production activities in cooperation with IBM.

ADNOC's smart growth strategy aims to drive business-wide growth and profitability by focusing on three areas in the coming years; more profitability upstream, more value downstream, and a more sustainable and cost-effective gas supply [50].

The technology allows storing data that can only be changed with the consent of the majority of the network, so that all participants are involved in processes such as verification and auditing of transactions.

The actors in the oil supply chain can be shown as drilling companies, refinery plants, refined oil storage, oil pump, other factories and common consumers. For example, blockchain technology can automatically record how much crude oil is sent from the production well to the refinery, or how much liquefied natural gas is exchanged between companies, or how much it is sold to customers at home and abroad. The actors of this flow and the relationship between them can be mentioned as follows:

- First, the drilling company will initiate a smart contract with the refinery factory with information about terms, quantity and product. Upon confirmation by both parties, transportation will begin and another smart contract will be launched for both parties to control and monitor. The contract will save this information automatically in the blockchain with the help of IoT devices.
- Both the refinery company and the drilling company can check for any procedural violations from the smart contract for monitoring.
- Then, the refinery factory will initiate its own smart contract, specifying the product information with the storage company.
- The storage company can initiate different smart contracts with other factories i.e. textile or mills and oil pumps.
- Finally, the oil pump will initiate product-information smart contract for the consumer and consumer check if there are any changes or violations before.
- All smart contracts will retain the information of the previous smart contract for procedural violation caused by tracking the smart contract.

Thanks to the end-to-end tracking process of products, it provides all information to all actors from anywhere at any time. When a distribution is initiated by a participant, situations such as the distribution started, continuing in the supply chain, any changes in the system are presented to the information of all participants of the blockchain. [51].

Chapter 5

Results

Blockchain technology represents the move from a centralized structure (banks, exchanges, trading platforms, energy companies) to a decentralized system (end customers, energy consumers) for lower costs, faster processes and more flexibility. The entire system becomes more flexible, as many jobs are now automated through smart contracts, according to blockchain technology. Theoretically, blockchain systems do not need intermediaries or central authority. However, blockchain technology is still immature and therefore still in development.

Today, blockchain technology is being tested with a small number of pilot projects financed by large energy companies, especially in the energy sector. For example decentrally generated energy was sold directly between neighbors via a blockchain system for the first time in New York in April 2016. The aim is to establish a completely decentralized energy system in which energy supply contracts are executed directly (without a third intermediary) and automatically between energy producers and consumers. In April of 2018, the Chilean National Energy Commission (CNE) announced the launch of a blockchain project focused on energy. The government uses the Ethereum blockchain to record, store, and track energy data.

When the legal aspect of blockchain technology is examined, it is important to ensure the protection of consumers in terms of increasing the use of the system. The legal impact of blockchain technology on consumers must continue to be evaluated as the technology advances and new use cases for consumers emerge. It takes time for the blockchain system to replace the traditional system, as it is not always easy to give up the traditional system. There are some of the current challenges, such as users' use of current legislation, the new introduction of a blockchain-based trading model, etc.

The blockchain system has certain advantages and disadvantages. Advantages are low transaction costs, transparency, simplicity, appreciation of local producers, while disadvantages are concerning arising from trust and security of information (loss, alteration and misuse) and relatively new technology.

Blockchain technology contributes to the market shares of individual consumers and manufacturers. It enables people who not only consume energy but also produce energy to buy and sell energy without the need for an intermediary.

In addition to being used to perform energy supply transactions, it can also provide opportunities for metering and billing processes. Starting with individual sectors first blockchain technology has the potential to radically change the conventional energy sector by transforming the entire energy market.

Societies' energy demand is increasing day by day, so it is vital that the production, the stages of energy production, storage distribution are carried out in a way that causes the least damage to nature and at a lower cost. Blockchain technology, which has been widely used in different sectors in recent years, is very promising for the energy sector. It is foreseen that blockchain technology will be used in many sub-branches of the energy sector such as electricity, oil and natural gas, and will provide many benefits. Blockchain technology is expected to play an important role in energy trading, supply chain optimization, management, chain of custody, data security and regulatory compliance. Blockchain technology has great potential in the oil and gas industry.

Transactions in financial systems are based on trust. In the traditional structure, trust is provided by the intermediary institutions between two parties in a financial transaction. Intermediary institutions always have the risk of not performing transactions for the benefit of the parties or performing them without their knowledge. In addition to the existing risks, the trust of the parties to the intermediary institutions was greatly shaken by the financial crisis experienced in 2008. Blockchain technology emerged in the economic crisis which led to a loss of confidence in a financial institution. Satoshi Nakamoto published the article in 2008 and introduced the blockchain technology, which was presented as a solution to the trust needs of the parties.

Blockchain technology allows transactions to be carried out peer-to-peer without intermediaries. By eliminating the intermediaries during the transactions, the trust needs of the parties are met, while saving costs and time. The advantages of blockchain technology are not limited to those mentioned above. In blockchain technology, transactions are recorded immutably against malicious tampering. In areas where maintaining data integrity is important, immutable recording of data is a huge advantage. The data recorded on the blockchain is public and transparent. In this way, every transaction is explained and the sense of trust provided by the system is reinforced. In addition, the fact that the data is recorded with distributed ledger technology increases the trust in the system.

The potential of blockchain technology is still being explored. This new technology, which has a wide area of use, provides many advantages and it includes many solutions that will improve the current business processes of not only the financial sector but also the non-financial sectors. It offers practical and economical solutions that will make life easier in many areas, such as realizing money transfer transactions within seconds and at a much lower cost, carrying out rental transactions over the internet without intermediaries and hassle-free, meeting the need not to change records in areas such as health and data storage where it is important to protect data integrity, and safely storing contracts by encrypting them in a digital environment.

The biggest obstacle to blockchain technology is prejudiced attitudes towards digital transformation. Like every innovation, blockchain technology has some risks and

disadvantages. As an example of the negativities that can be experienced; the problems such as the lack of specialization because it is in the development stage, the absence of policies determining its framework, the problems experienced in the process of integrating into traditional systems and the extension of the processing time of consensus mechanisms can be given. However, these problems can be solved with improvements and investments. Blockchain technology has the potential to make life easier and become the technology of the future. For this reason, it is to be developed and used in business processes instead of being thrown into the background due to these deficiencies.

When we examine the blockchain technology applications in the world, it is seen that it is generally used in the financial sector. This application is also seen in sectors such as logistics, food and health, and in the field of foreign trade, albeit limited. The USA, England, EU countries, China, Japan, Dubai and Singapore use blockchain technology in almost every field and have reached a certain level in the use of this technology. Turkey is still behind these countries. For the first time in Turkey, Akbank started to use this technology in international money transfer in the finance sector and there are some initiatives for the use and dissemination of this technology. In the field of foreign trade, although there is no application in Turkey yet, projects for the use of this technology are carried out. With these projects, it is foreseen that all documents for foreign trade will be digitalized by adapting to this technology. Thus, making transactions in a reliable network, error-free and at a low cost in the shortest time will provide great advantages in terms of Turkey's foreign trade and economic growth. In the use of blockchain technology, the government's support and practices will be important for Turkey to become one of the leading countries and increase its competitiveness.

In Turkey, studies on the blockchain have been started by the Ministry of Commerce in 2016. In terms of the Turkish economy, it is thought that this application will be used as an important tool that will create high added value within the scope of digital transformation in foreign trade transactions. With the new system to be introduced, all information regarding foreign trade will be shared over the blockchain and there will be a significant shortening of the entry and exit times of the products. With this

application, since the data will reach the receiving country from the source, the workload of verifying the accuracy of the data in the exit country will also be eliminated. Thus, possible tax losses will be prevented.

For the rapid development of blockchain technology, this technology should be included in tax systems. In this context, if a blockchain technology is legally secured, it will be able to benefit from both national and international taxation. Although it is not a solution for the entire tax system, it can be used in many applications in terms of tax collection and narrowing the tax gap with administrative burden and less cost and can increase trust in the system.

For a transaction to be valid on a legal basis, it must be approved by the state authority. So that a transaction is valid on a legal basis, it is considered that the blockchain system also allows the government to verify and approve transactions.

Chapter 6

Conclusions

The following conclusions were drawn in the study.

- Blockchain technology; while it has advantages such as low transaction costs, transparency, simplicity, and appreciation of local producers; Concerns arising from trust and security of information (loss, alteration and abuse) and the newness of the system also appear as disadvantages.
- Europe and Asia are the strongest countries in promoting blockchain in the oil and gas industry, BP and Shell are pioneers in this field.
- Currently, the application of blockchain in the oil and gas industry is still in the experimental stage, and many people in the oil and gas industry cannot adequately anticipate the benefits of this technology.
- Blockchain technology can bring many opportunities to the oil and gas industry, such as lowering transaction costs and increasing transparency. However, it faces many challenges and needs to address many technical and regulatory issues.
- Blockchains can have operational, legal and cyber risks in the oil and gas industry.

- Considering that the blockchain technology may take place widely in the energy sector, especially in the oil and natural gas industry, as in many other sectors, it is very important that the updates in the sector are based on a legal basis. For this reason, it is considered that there is an essential need to carry out legislative work on production, licensing, distribution and sales in the Geothermal Resources and Natural Mineral Waters Law No. 5686 and the regulation regarding the implementation of this law. In this way, businesses that will use the blockchain system will be able to act more bravely in the implementation of the system, effectively use all the data related to the business, and implement the stages in the whole process from production to sales on a legal basis.

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