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Smart Contracts in the Oil, Gas and Petrochemical Industry

Reza Mohammadi[1]

[1] *MSc Industrial Management (Production & Operation Management), Faculty of Management and Accounting, Shahid Beheshti University, Tehran, Iran*

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ABSTRACT

Purpose: A smart contract represents an agreement between parties that exploits a blockchain as the enforcing medium, limiting or avoiding the need of a legal enforcement (e.g., a court). The purpose of this paper is the review advantage and challenges of smart contracts on Oil, Gas & Petrochemical Industry.

Methodology: This paper does a systematic review to discuss the application prospects of blockchain technology in the oil, gas & Petrochemical industry.

Findings: The results show that the smart contract would be effective in Oil, Gas & Petrochemical industry.

Originality/Value: Finally, we note that, despite its significant potential, smart contracting is still a developing technology and has several open challenges associated with its implementation, such as privacy concerns, risk of cyber-attacks (such as hacking) and the energy required for computation and blockchain deployment of the contracts. So far, smart contract applications in energy systems have been mostly focused on research, proof-of-concept and demonstration projects (such as P2P demonstration projects run in a local community or microgrid).

1. Introduction

In the early 20th century, following the strive of Western oil companies to exploit oil in oil-rich countries, abusing their ignorance, to obtain long-term concessions in oil exploration and extraction at low prices, the formation of the United Nations (UN) and its General Assembly provided an opportunity for such countries to raise citizens' right of self-determination in economic and social policies and

[1] Corresponding Author: Rez.Mohammadi@Mail.sbu.ac.ir

permanent sovereignty over wealth and natural resources as public will through UN statements, and turn it into a well-known principle in international law [1] . An organization's competitive advantage can be viewed as the ability, gained through resources and attributes, to perform at a higher level than competitors in the same market. Establishing a Sustainable Competitive Advantage in today's dynamic environment involves optimizing an organization's exploration and exploitation strategy [2] . In a smart contract, contract clauses written in computer programs will be automatically executed when predefined conditions are met. Smart contracts consisting of transactions are essentially stored, replicated and updated in distributed blockchains. In contrast, conventional contracts need to be completed by a trusted third party in a centralized manner consequently resulting in long execution time and extra cost. The integration of blockchain technology with smart contracts will make the dream of a "*peer-to-peer market*" come true [3] .

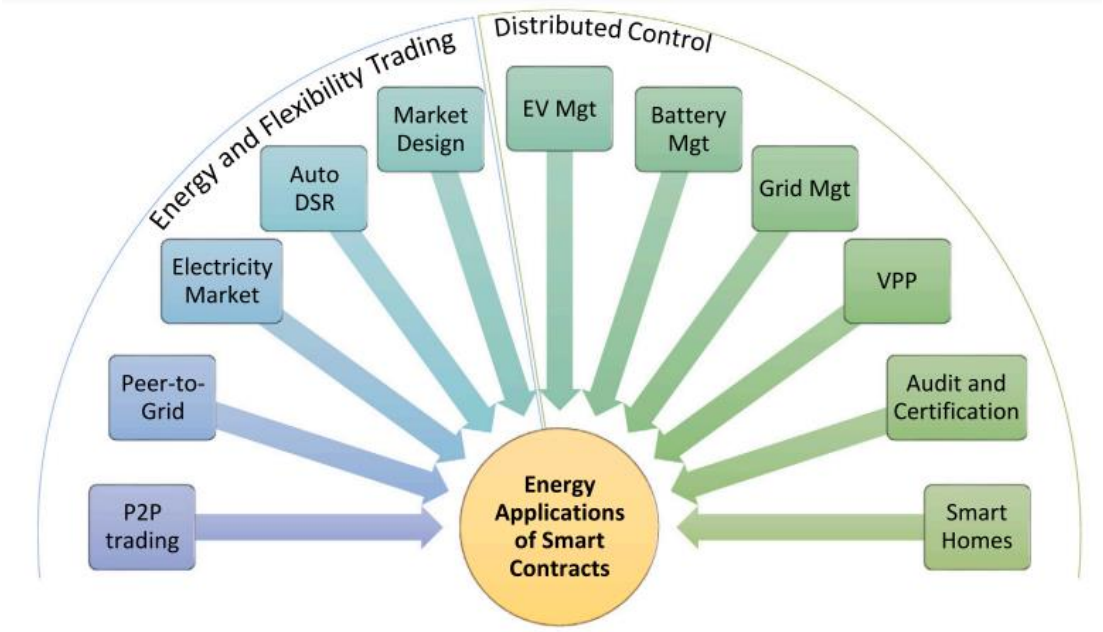

Figure 1. Application of smart contracts in the energy sector. Each application is discussed in one of the two main application categories identified which are (1) energy and flexibility trading and (2) distributed control [4]

2. Oil, Gas and Petrochemical Industry

Economic analyses can help decision makers to decide the best approach to monetize gas resources. This can focus on fuels, like ethane-rich natural gas and liquefied petroleum gas (LPG), or petrochemical feedstocks, like lean natural gas, pure ethane and propane. Fuels such as LPG are the usual choice of natural gas processing facilities, although market changes may require new strategies concerning how natural gas richness is explored. Since petrochemicals are a non-carbon emitting use of fossil fuels, at least if dedicated to long-lasting materials, its profitable production could endure even in greenhouse gas emissions restriction scenarios. In addition, Platts (2021) estimates that world natural gas use in chemicals and plastic could increase from 4.8 boe/d in 2020 to 15.9 boe/d in 2050, and refined oil in chemicals and plastic production will increase from 17.9 in 2020 to 28.7 boe/d. Besides naphtha, both ethane and propane are relevant petrochemicals feedstock [5] . Oil, Gas & Petrochemical Industry have three stages:

1) Upstream: It is more inclined towards the exploration and production of the OaG. It includes finding a good place from which the companies get a fair amount of OaG. Later on, the production stage covers the extraction of hydrocarbons and non-saleable materials from the mixture of liquid hydrocarbons, gas, some solids, and water. At the end of this stage, companies can get the raw materials for selling.

2) Midstream: It mainly incorporates the transportation of products to the sellers. There are clusters of pipelines and transportation of vehicles through which the transportation is carried out from the wholesalers and sellers.
3) Downstream: It purifies the raw material received from the upper streams and separates the OaG. According to the user's requirement, the process is carried out to sell to the consumers and end-users. The demand for OaG in countries like India and Europe has rapidly increased up to 95% in the various organization for economic co-operation and development (OCED). To meet these requirements, the proper execution of the aforementioned streams is required [6]

3. Smart Contracts

Smart contracts (i.e., agreements enforced by a blockchain) are supposed to work at *lower* transaction costs than traditional (and incomplete) contracts that instead exploit a costly legal enforcement [7] . Smart contracts –self-executing scripts that reside on the blockchain– integrate these concepts and allow for proper, distributed, heavily automated workflows. This should make blockchains enticing to researchers and developers working in the Internet of Things (IoT) domain [8] . Smart contracts (SCs) are an important component in blockchain applications: they are programmatic agreements among two or more parties that cannot be rescinded. Furthermore, SCs have an important characteristic: they allow users to implement reliable transactions without involving third parties. However, the advantages of SCs have a price. Like any program, SCs can contain bugs, some of which may also constitute security threats. Writing correct and secure SCs can be extremely difficult because, once deployed, they cannot be modified. Although SCs have been recently introduced, a large number of approaches have been proposed to find bugs and vulnerabilities in SCs [9] .

Such smart contracts have increasingly been gaining ground, finding numerous important applications (e.g., crowdfunding) in the real world. Despite the increasing popularity, smart contract development still remains somewhat a mystery to many developers largely due to its special design and applications. Are there any differences between smart contract development and traditional software development? What kind of challenges are faced by developers during smart contract development? Questions like these are important but have not been explored by researchers yet [10] . Ethereum is a most generally used Turing Complete blockchain platform, which allows developers to write a smart contract with their own random rules for ownership, transaction format, and state transition functions. Anyone can run an Ethereum node, on their machine to participate in the Ethereum blockchain network. Figure 1 describes the layered architecture of the Ethereum blockchain [11] .

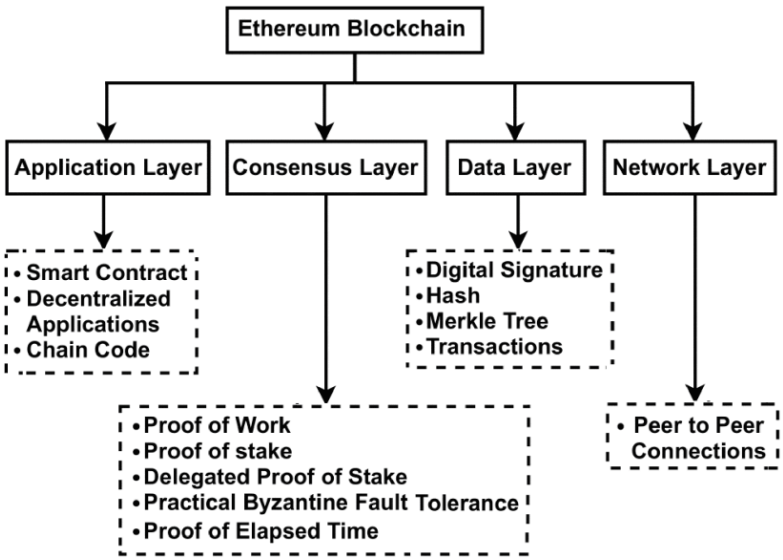

Figure 1. Layered Structure of Ethereum Blockchain [11]

3.1. Block Chain

Block chain, which is a new technology of the future, is emerging as a new paradigm to change existing business processes [12] . Blockchains allow us to have a distributed peer-to-peer network where non-trusting members can interact with each other without a trusted intermediary, in a verifiable manner [8] . The blockchain technology has been in the limelight with the emergence of bitcoin and since then it is attracting huge interest and investment across industries. The blockchain technology is a decentralized and a distributed-leger technology in which all the information or transactions are digitally stored in a secure environment across different locations and people [13] . In recent years of development, the interest in Blockchain technology and the essentials of its application have made it popular. The efficiency and availability of this technology have made it a widely accepted technology. Blockchain technology has completely changed the present-day concept of centralization. Different methodologies are used for the purpose of interfacing and monitoring the transactions in blockchain technology. Decentralization, immutability, transparency, and peer to-peer communication help to address the current trends effectively [14] .

Blockchain has been recognized as one of the most promising technologies since the advent of Bitcoin in 2008. A blockchain encapsulates data into blocks, and these blocks form a linked list in the order specified by a distributed **consensus** mechanism. The chain structure and the decentralized nature grant many favorable features to blockchain, such as transparency, traceability, and immutability, which explains the widespread application of blockchain in various fields. In peer-to-peer (P2P) transactions, using blockchain can reduce transaction cost by getting rid of centralized trusted intermediaries. The traceability, transparency, and immutability make blockchain very popular in commodity tracing. Blockchain can also establish trust and provide data security for cloud computing or edge computing, supply chains, and health care systems. With the proposal of “Blockchain 2.0” in 2014, the development of the blockchain technology embraces a new climax. Compared with Blockchain 1.0, Blockchain 2.0 integrates smart contracts, a kind of programmable scripts that execute automatically when predefined conditions are met. As a result, the application scope of blockchain has been further extended to automatic transaction settlement, system access control, content copyright protection, and many other services. As one of the most popular ICTs at the moment, blockchain is playing an important role in the revolution of modern energy systems. The blockchain applied in energy systems is also called **energy blockchain**. In P2P energy trading scenarios where untrusted entities are involved, energy blockchain can guarantee trading transparency and privacy in the absence of trusted intermediaries. In electric vehicle (EV) charging systems, blockchain can support secure energy exchange and efficient demand response. With the help of smart contracts, energy blockchain enables automation, decentralization, and flexibility in the control and management of energy systems [15] .

3.2. Block Chain & Smart Contracts in Oil, Gas & Petrochemical Industry

Internet help the people all of the world to reach the numerous of data at a glance [16] . Cryptocurrencies record transactions in a decentralized data structure called a blockchain. Two of the most popular cryptocurrencies, Bitcoin and Ethereum, support the feature to encode rules or scripts for processing transactions. This feature has evolved to give practical shape to the ideas of smart contracts, or full-fledged programs that are run on blockchains. Recently, Ethereum's smart contract system has seen steady adoption, supporting tens of thousands of contracts, holding millions of dollars’ worth of virtual coins [17] . The concept of Blockchain comes from the idea of an immutable and decentralized system. It is a distributed ledger technology (DLT) for a trustless environment [18] . An appealing feature of blockchain technology is smart contracts. A smart contract is executable code that runs on top of the blockchain to facilitate, execute and enforce an agreement between untrusted parties without the

involvement of a trusted third party [19] . Blockchain technology provides decentralized consensus and potentially enlarges the contracting space through smart contracts. Meanwhile, generating decentralized consensus entails distributing information that necessarily alters the informational environment [20] . In recent years, the number of event studies in IS research has increased and the focus has been extended beyond IT investments to other issues, such as security incidents, IT outsourcing initiatives, Web traffic, and standardization projects [21] .

As oil and gas resources play an essential role in the energy field, the technologies of the oil and gas industry have also developed rapidly in recent years, such as intelligent drilling technology, intelligent oil and gas fields, and marine digital platforms. It can be seen that the oil and gas industry is gradually developing towards the direction of intellectualization, digitalization, and automation. However, its management mode is relatively old, and it has the characteristics of low efficiency, high cost, long period and high risk [22] . For example, since the oil and gas industry is a huge system, it involves multi-party transactions and trade, the paperwork and reconciliations generated in each link are very cumbersome and error-prone. In summary, the management issues of the oil and gas industry mainly involve the following four aspects:

- A large amount of paperwork and reconciliation work increases the monetary and time costs of the transaction.
- The oil and gas industry has the characteristics of multi-party investment and cooperation, and the risks of fraud, error, and inefficiency in transactions are relatively high.
- The third-party management costs in the oil and gas trade are relatively high, the trade negotiation process is inefficient, and the exchange of critical data is slow.
- Important data is at higher risks from cyber-attacks.

Based on the above problems, it is time for the oil and gas industry to change its management mode. A relatively new technology called blockchain has been found to have great potential for use in the oil and gas industry [23] .

4. Research Background

Mittal & Kudapa (2023) Review a short review on the application of blockchain technology in petroleum industry. The implementation of blockchain technology in petroleum industry is still at a nascent stage but it has the potential to completely transform and disrupt the petroleum industry. This paper reviews the characteristic features, merits and demerits of different types of blockchain, the design principle of any blockchain technology, potential application and various use cases of blockchain technology in petroleum industry [13] . Li et al (2022) used Artificial Intelligence to Oil and Gas Development. In this paper in order to dig up more about the applications of artificial intelligence in oilfield development for a hint of the future trend of this exciting technology in oil and gas industry, literature investigation of a large amount of AI-based work reported has been conducted in this work. Based on the investigation, the application of AI in important issues in oilfield development including oilfield production dynamic prediction, developing plan optimization, residual oil identification, fracture identification, and enhanced oil recovery are specifically investigated and summarized, the backs and cons of existing AI algorithms has been compared. Based on the analysis and discussion, current situation of the application of AI in oilfield development is concluded, and suggestions and potential directions of future work AI application in oil and gas developing are provided [24] .

Gupta & Shah (2022) investigate how artificial intelligence modifies a huge piece of the energy area, the oil and gas industry. This paper attempts to evaluate technical and non-technical factors affecting the adoption of machine learning technologies. The study includes machine learning development platforms, network architecture, and opportunities and challenges of adopting machine learning technologies in the oil and gas industry. The authors elaborate on the three different sectors in this industry namely upstream, midstream, and downstream. Herein, a review is presented to evaluate the applications and scope of machine learning in the oil and gas industry to optimize the upstream operations (including exploration, drilling, reservoir, and production), midstream operations (including transportation using pipelines, ships, and road vehicles), and downstream operations (including production of refinery products like fuels, lubricants, and plastics). Enhanced processing of seismic data is illustrated which provides the industry with a better understanding of machine learning applications. Basing on the investigation of AI implementation prospects and the survey of subsisting implementations, they diagram the latest patterns in creating AI-based instruments and distinguish their impacts on speeding up and de-gambling measures in the business. They examine AI proposition and calculations, just as the job and accessibility of information in the portion. Furthermore, they examine the principal non-specialized difficulties that forestall the concentrated use of man-made brainpower in the oil and gas industry (OGI), identified with information, individuals, and new types of joint effort. They additionally diagram potential situations of how man-made reasoning will create in the OGI and how it might transform it later on (in 5, 10, and 20 years) [25] .

Zheng et al (2020) review an overview on smart contracts: Challenges, advances and platforms. smart contracts enable the contractual terms of an agreement to be enforced automatically without the intervention of a trusted third party. As a result, smart contracts can cut down administration and save services costs, improve the efficiency of business processes and reduce the risks. Although smart contracts are promising to drive the new wave of innovation in business processes, there are a number of challenges to be tackled. This paper presents a survey on smart contracts. We first introduce blockchains and smart contracts. We then present the challenges in smart contracts as well as recent technical advances. We also compare typical smart contract platforms and give a categorization of smart contract applications along with some representative examples [3] . Lu et al (2019) investigate the Blockchain Technology in the Oil and Gas Industry: A Review of Applications, Opportunities, Challenges, and Risks. This paper first presents the relevant theories and core technologies of the blockchain, and then describes how the blockchain is applied to the oil and gas industry from four aspects: trading, management and decision making, supervision, and cyber security. Finally, the application status, the understanding level of the blockchain in the oil and gas industry, opportunities, challenges, and risks and development trends are analyzed. The main conclusions are as follows: 1) at present, Europe and Asia have the fastest pace of developing the application of blockchain in the oil and gas industry, but there are still few oil and gas blockchain projects in operation or testing worldwide; 2) nowadays, the understanding of blockchain in the oil and gas industry is not sufficiently enough, the application is still in the experimental stage, and the investment is not enough; and (3) blockchain can bring many opportunities to the oil and gas industry, such as reducing transaction costs and improving transparency and efficiency. However, since it is still in the early stage of the application, there are still many challenges, primarily technological, and regulatory and system transformation. The development of blockchains in the oil and gas industry will move toward hybrid blockchain architecture, multi-technology combination, cross-chain, hybrid consensus mechanisms, and more interdisciplinary professionals [23] .

5. Findings

The stakeholders in the Oil, Gas & Petrochemical industry demands a secure, reliable, and decentralized platform for their numerous royalty transactions. At the same time, maintaining the privacy and security of the end-users are also the key challenges. Moreover, effective decision must be carried out and thoroughly analyzed to resolve the aforementioned issues. This paper proposed a blockchain-based scheme, which securely executes the royalty transactions among various stakeholders in Oil, Gas & Petrochemical industries. The secure royalty contract transactions are one of the key contributions of the proposed scheme. We also evaluated and validated the performance of the proposed scheme and functionalities of the proposed smart contract through experimental results [26] . Globally, Blockchain has been registering unparalleled growth recently owing to the increasing demand for cryptocurrency and growing digitalization. However, the future cannot be foreseen [26] . Blockchain is increasingly becoming too compelling a technology that can't be ignored for the oil & gas sector as it can offer new approaches to services contracts, price discovery, and the entire transaction life cycle, which results in potential cost savings and process efficiencies. Besides, the benefits of Blockchain in oil and gas industry also reflect in the form of improved transparency, efficiency, and data security. Blockchain in the oil & gas industry offers many advantages to companies, first & foremost being the near-real-time recording of transactions and visibility among participants, eventually leading to reduced risks. Data integration helps in eliminating any chances of double spending, fraud, or manipulation.

Conflicts of Interest

None.

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