The Future of Oil and Gas Offloading: Leveraging Blockchain for Enhanced Transparency and Efficiency

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Abstract: In the dynamic and complex arena of the oil and gas sector, the management of offloading activities presents considerable challenges, particularly regarding data transparency, distribution, security, and financial transactions involving multiple parties, e.g., companies in a joint venture. The nature of multiple-party environments requires a high level of systematization, transparency, and activity orchestration to manage these challenges effectively. To address these challenges, this paper explores an innovative solution employing blockchain technology, creating efficient mechanisms to enhance transparency and the security of recorded transaction. The solution specifically focuses on the processes of oil production recording, lifting schedule management, and the intricate handling of loans and refunds. We underscore the criticality of managing loans and refunds to facilitate the lifting process, ensuring equitable oil volume distribution among consortium members. Thus, this work presents a comprehensive blockchain-based system that provides the accuracy and integrity of data, enhancing transparency and trust among consortium participants. This system seamlessly integrates all stages of offloading operations, from planning to execution, thereby revolutionizing crucial data management practices in the oil and gas sector by applying blockchain technology. Our findings suggest that implementing such technology in this context fosters a collaborative, trustworthy, secure, and efficient operational environment.

1 INTRODUCTION

FPSO (Floating Production, Storage and Offloading) technology is a widely used method for extracting offshore oil and gas (O&G) reserves (Gaidai et al., 2021). The offloading process in an O&G consortium gathers activities from lifting planning to lifting execution. This process faces a variety of challenges in integrating not only internal data, but also data from other companies. These challenges mirror the complexities found in ERP (Enterprise Resource Planning) systems, where the integration of diverse data streams across departments is crucial (LaGrange and Maisey, 2019; Son and Lee, 2019). In the offloading process, this integration encompasses coordinating approvals, auditing activities, and managing the flow of process of data across multiple companies (Araújo et al., 2019). This intricate task requires a system capable of handling diverse expectations and operational protocols.

In 2013, the exploration of the Mero unitized field in Brazil's pre-salt area commenced under the Production Sharing Agreement (PSA). This marked a crucial milestone in Brazil's oil sector and it was a key aspect of the government's inaugural bidding round (Carlotto et al., 2017). Libra was the winning consortium to explore the Mero unitized field. Such consortium is formed by Petrobras, responsible for operating the joint venture, Shell Brasil, TotalEnergies, China National Petroleum Corporation (CNPC) and CNOOC as partners, and Pre-Sal Petróleo S.A (PPSA), representing the Federal Government (de Melo et al., 2019; Nasser et al., 2020). Petrobras recently achieved a milestone with FPSO Guanabara, recording its highest monthly production on a pre-salt platform with 179 thousand barrels per day[1]. Such achievement is a strong evidence of the

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production potential of this field, which means a considerable high amount of generated data.

In regards to offloading activities, efficiently managing and transparently distributing critical data related to oil production, lifting schedules, and execution, including financial aspects like loans and refunds, presents a significant challenge. The involvement of numerous consortium members, operators and non-operators, often results in high human resource costs for recording and managing these activities, as well as keeping consortium companies informed.

In this sense, blockchain technology emerges as a solution to these challenges. Its decentralized approach and immutable ledger provide a framework for transparent and efficient process management, addressing transparency, data integrity, and trust among consortium members. Moreover, the oil and gas industry has implemented blockchain technology in several instances. This indicates the recent adoption of this technology in this sector (Miranda et al., 2023; Alves et al., 2022; Batista et al., 2023).

OffloadingBR was developed to leverage blockchain technology for offloading operations in the O&G sector. This system, built on the Hyperledger Fabric (HF) platform (Kumar and Barua, 2023), offers a permissioned network for secure and transparent data management. It integrates key offloading operations, including production volume recording, lifting schedule management, and handling loans and refunds. With smart contract functionality, OffloadingBR automates contractual obligations and operational rules to improve transparency and efficiency.

This paper is structured as follows. Section 2 focuses on the Libra consortium application context, and section 3 discusses the related work. Section 4 presents the OffloadingBR solution, while section 5 discusses the use of a private blockchain network. Section 6 presents the solution limitations. Finally, section 7 presents the conclusion and future work.

2 APPLICATION DOMAIN

As mentioned before, the Mero field model, formalized under the PSA, was part of the first bidding round of the pre-salt organized by the Brazilian government (Carlotto et al., 2017).

The Mero unitized field is explored by the Libra consortium, composed by Petrobras, serving as the Operator with a 38.6% stake, Shell Brasil and TotalEnergies, each holding 19.3%, and CNPC and CNOOC, each with a 9.65% share, and PPSA with a 3.5% of participation.

According to the PSA, the distribution of produced oil volume follows a defined structure. Each cubic meter (m^3) of oil produced in an FPSO is proportionally divided, with PPSA entitled to its share of oil profit, and the remaining volume following the proportion foreseen in the PSA.

A collaborative research, development and innovative project was initiated with the Pontifical Catholic University of Rio de Janeiro (PUC-Rio), in compliance with the research and development obligation foreseen on the PSA[2]. Aiming to pursue technological innovation within the Libra consortium, this project focuses on leveraging blockchain technology to enhance operational efficiency and transparency. This collaboration resulted in the development of the OffloadingBR, a blockchain-based offloading system, which will be presented on the following sections.

3 RELATED WORK

This section provides an overview of the current state of the art in digital innovations in the O&G sector. It particularly focuses on core industry activities, such as offloading, consortia deliberation process, and other activities associated with FPSO's. The goal is to highlight the advancements and identify possible gaps compared to our solution.

Yasseri and Bahai present a system, with an engineering approach, emphasizing the need for efficient interface management (IM) during the design phase to minimize late changes and ensure cost-effectiveness (Yasseri and Bahai, 2019). This paper also mentions that an effective IM system shall handle the complex data requirements of FPSO projects. These systems must be capable of capture, store, and process large volumes of diverse data to support decision-making and project management. In this sense, OffloadingBR represents an advancement in coordinating the planning, execution, and oversight of loan and refund op-

guanabara-breaks-pre-salt-production-record/

[2]The RD&I Clause is an obligation foreseen in exploration, development, and production of oil and natural gas agreements. Such obligation is regulated by the National Petroleum Agency (ANP). Under concession agreements, the RD&I clause establishes that the concessionaire must disburse expenses qualified as research and development, corresponding from 1% to 0.5% of the gross revenue of the camp production due to Special Participation. Regarding the sharing agreement and onerous concession, the value varies from 1% to 0.5% of the annual gross revenue of the oil camp

erations, contributes to managing FPSO data effectively.

Affonso et al. highlight how traditional document-centric processes in engineering can be replaced by a data-centric approach, enhancing quality, consistency, and reducing design costs and time (Affonso et al., 2020). The authors discuss the significance of R&D and digital innovation across many organizational sectors, emphasizing the need for workforce engagement and mindset change to appreciate digital technologies. In this sense, blockchain technologies can address these needs in R&D projects with the collaboration between the university and industry, e.g., OffloadingBR built under the Libra Consortium collaboration with a Brazilian university.

Duggal and Minnebo detail the adaptability of FPSOs in various offshore oil-producing basins, highlighting technological advancements, key projects, and future trends, including digitalization and carbon footprint reduction (Duggal and Minnebo, 2020). In this sense, OffloadingBR proposes digitalization by developing a blockchain-based solution, allowing data persistence, transparency, and distribution.

The authors in (Cotrim et al., 2022) show improvements in data simulation in offloading activities. The study demonstrates that Artificial Neural Network (ANN) models trained on actual metocean conditions[3] can provide increased accuracy and reduce computational time compared to traditional methods. This approach also allows for continuous fine-tuning and updating models with new data, improving accuracy over time. The authors also highlight the importance of data acquisition, specifically concerning the sensitivity and restrictions on the complete dataset used in the research. Thus, OffloadingBR is a first step towards a data lake construction related to offloading activities.

These studies highlighted the evolution from traditional, document-centric processes to innovative data-centric approaches with the use of blockchain technology in O&G consortia. Systems such as OffloadingBR represent a milestone regarding registration and distribution of complex data, as well as coordination of operations in a multiparty environment.

[3]Metocean conditions refer to the combined wind, wave, and climate conditions in a particular location.

4 A BLOCKCHAIN-BASED SOLUTION FOR OFFLOADING ACTIVITIES

In the contemporary O&G sector, a significant challenge lies in the efficient management and transparent distribution of critical data regarding (i) oil production, (ii) lifting schedule, and (iii) lifting execution, which includes financial transactions such as loans and refunds. The complexity of these operations, involving multiple consortium members with different roles, often leads to high human resource costs, specially for the Operator, responsible for leading this process.

The complexity involved in the lifting and offloading life cycle happens because when a lifting occurs, each cubic meter (m³) of oil must be proportionally distributed among its members according to each member's participation as foreseen in the PSA. With some exceptions, the withdrawal of the produced oil is commonly carried out by one company at a time. Considering that, as a rule, only a single ship will perform the offloading. However, such ship has a limited cargo capacity. Also, each cubic meter belongs proportionally to each company in the consortium, therefore, the oil lifting involves, simultaneously, a relief and a mutual action. For example, let's consider a scenario where a ship has a capacity of 80,000 m³, but Company A only possesses 40,000 m³ of produced oil. To address this imbalance and optimize shipping efficiency, the Operator plays a crucial role in managing loans between consortium companies. This process enables Company A to borrow the required volume of oil from other members, thereby fully utilizing the ship's capacity of 80,000 m³..

The lifting process involves recording oil production and management of lifting, loan, and refund, such as: importing production and stock values, organizing dates and ships' authorization for oil lifting, calculating and predicting loan and refund values, and informing other consortium companies. Considering that this involves crucial business information, the process and calculus must be flawless, since any error can seriously impact the lifting, causing relevant money loss.

To facilitate the management of the lifting and offloading process, we conducted several meetings with the Operator's stakeholders in 2022 and 2023 to address these challenges. These meetings accelerated the agile development of the system, by enabling rapid stakeholder feedback and fast system development. Two challenges emerged during these meetings: the need to automate the process and data sharing with consortium members. The automation

was important to increase efficiency, security and data availability, since most of the activities were manually done. Data sharing was important to assure transparency of core business data between consortium members, enhancing trust between them.

Using blockchain technology in this context provides a transparent, secure, and efficient mechanism for recording these transactions. Each loan and volume of oil exchanged are recorded on the blockchain ledger. This ensures that all transactions are transparent and immutable, thus maintaining the integrity of the PSA and fostering trust among the consortium members.

The blockchain's ability to provide a transparent and auditable trail of these transactions is pivotal in these complex logistical operations. The intricate process of managing oil production, lifting, loans, and refunds within the consortium lends itself perfectly to the capabilities of blockchain technology.

Furthermore, the blockchain smart contracts ensure that all actions, from loan issuance to oil volume distribution, strictly adhere to the PSA. Thus, compliance is assured by the agreed-upon terms implemented in the smart contracts.

The decentralized nature of blockchain requires that any creation or modification of these smart contracts must receive the consensus of all network participants, thereby ensuring unanimous agreement and commitment to the terms set forth. By embedding these operational rules within the blockchain, the technology ensures transparency, efficiency, and security, eliminating the potential for disputes and discrepancies. The immutable and transparent nature of blockchain, combined with the enforceability of smart contracts, revolutionizes how consortium members interact, transact, and maintain compliance.

4.1 Recording Oil Production

The first step towards offloading activities in the O&G consortium involves registering oil production data in a daily basis. In this phase, the consortium Operator is responsible for registering production data and distributing the oil m³ for each member company. This information includes the volume of oil produced by each company. The latter forms the basis for determining subsequent lifting schedules and allocations. Leveraging blockchain technology in this context is particularly advantageous. Once the Operator inputs the production data into the blockchain system, it is instantly and automatically disseminated across the entire network, becoming immutable.

Consortium members, including non-operators, can access the blockchain ledger to verify production volumes, ascertain which company is scheduled for lifting, and understand the quantity of oil allocated for each lift. The blockchain's immutable ledger ensures that, once recorded, the production data cannot be altered, thus confirming its accuracy and reliability. This process not only streamlines the decision-making regarding oil lifting but also fosters a high degree of trust among consortium members by providing a transparent and indisputable oil production record.

4.2 Lifting Schedule Steps

The second stage is related to lifting schedule management. This comprises four major steps: (i) entitlement determination, (ii) cargo nomination, (iii) provisional lifting schedule, and (iv) final lifting schedule, as depicted in Figure 1.

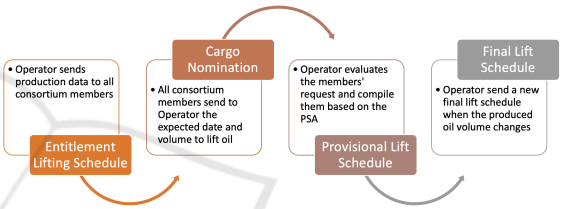

Figure 1: Lifting planning steps.

The entitlement determination involves the Operator disclosing to the consortium members the lifting activities. This includes three key information components: (i) an estimate of the oil production for the upcoming two months, (ii) planned liftings for the current month, and (iii) a balance of the oil stock of the past three months. This information is crucial for all subsequent decisions regarding lifting schedules. The entitlement determination process is designed to give all consortium members a clear and comprehensive overview of available resources, upcoming production, and current stock. This ensures that all parties are equally informed and that the lifting process can be planned efficiently and equitably.

Following the entitlement determination, the next step involves consortium members setting cargo nomination values for the Operator individually, i.e., the values are not public; only the Operator can access the suggested values. The cargo nomination includes details about the date and volume of oil available for lifting. Upon receiving these nominations, the Operator initiates the next step, i.e., the provisional lifting schedule. In this step, the Operator reviews and publishes the lifting schedule. All consortium members can also review and, if necessary, request updates while justifying the reasons for the change. This step is crucial for maintaining transparency and fairness in

the allocation process, confirming the requested cargo nominations and ensuring compliance with the agreement rules. In cases where updates are required, the Operator review the nominations to reflect accurate dates and volumes before sending the provisional lifting schedule. This schedule is an initial plan, laying out the framework for how and when the lifting activities shall be executed according to the current knowledge of oil production and contract rules.

The final phase in the lifting schedule management involves the Operator finalizing and sharing the lifting schedule. This final schedule is informed by the current production volume data and projections for the following months, up until when the lifting is executed. It is essential for this schedule to be both accurate and adaptable, as it guides the operational planning for all consortium members. Recognizing the dynamic nature of oil production, the Operator periodically updates the final lifting schedule. These updates are particularly important when the actual volume of oil produced deviates from initial forecasts. By continuously adjusting the schedule to reflect the most updated production data, the Operator ensures that the lifting process remains aligned with the actual output, thereby maximizing efficiency and minimizing discrepancies.

A pivotal element in managing the lifting schedule is the requirement of digital signatures at each step, ensuring the authenticity and non-repudiation of the agreed-upon schedules and transactions. To address this need, our proposed solution supports compatibility with two distinct digital signature solutions: AssinadorBR (Paskin et al., 2020) and Adobe Sign[4].

AssinadorBR is a cutting-edge, blockchain-based application that offers integration with HF, Hyperledger Besu, Ethereum, and Amazon Quorum DB. The financial implications of using AssinadorBR vary depending on the chosen blockchain platform. For instance, choosing HF incurs no transaction cost. On the other hand, Adobe Sign presents a more traditional digital signature approach, anchoring user identity to email addresses. It operates on a different cost structure based on the signature package selected from Adobe. Providing these two diverse digital signature options empowers the consortium Operator with the flexibility to choose the solution that best aligns with their operational needs and cost considerations.

[4]https://www.adobe.com/sign.html

4.3 Lifting Execution with Loans and Refunds

The success of O&G lifting depends on the efficient management of loans and refunds during execution. In this phase, the Operator orchestrates loans to enable the lifting company to match the capacity of its ship with the production volume of the FPSO. These loans are proportionately distributed among partners holding a positive oil stock relative to their production volume.

As presented in Eq. 1, *PSLV* (Partners Suggested Loan Volume) is a result of the lifter required volume (V_{Req}) times the volume available to lend (VAL_i) divided by the sum of all partner produced volume (PPV), where i is a specific company and n is the number of consortium members. This calculus guarantees that all partners are lending the proportional oil volume related to how much was produced. Moreover, the data integration between produced volumes with lifting execution allows the system to suggest volume values so that the Operator can register it, enhancing process transparency and activities efficiency.

$$PSLV_i = V_{Req} \times \left(\frac{VAL_i}{\sum_{j=1}^{n} PPV_j} \right) \tag{1}$$

A vital aspect of this system is the timely repayment of loans. Ideally, it shall happen before subsequent lifting activities, to steadily clear any outstanding balances. Eq. 2 presents how refunds are calculated. *PSRV* (Partner Suggested Refund Volume) is a result of the Volume Produced by the Lifter ($V_{ProducedByLifter}$) in a certain time range times the Partner's Pending Loan Volume ($PPLV_i$) divided by the sum of Partners Borrowed Volume (PBV), where i is a specific company and n is the number of consortium members.

$$PSRV_i = \begin{cases} PSRV_i, & \text{if } PSRV_i \leq PPLV_i \\ PPLV_i, & \text{otherwise} \end{cases} \tag{2}$$

where $PSRV_i = V_{ProducedByLifter} \times \left(\frac{PPLV_i}{\sum_{j=1}^{n} PBV_j} \right)$.

The refund process is equally intricate, where payments are distributed proportionally among loaners, except in cases where the next lifter has open loans, i.e., loans that were not paid off completely. In such scenarios, the lifter with open loans is prioritized for maximum refund, while the remaining volume is redistributed among other loaners. Figure 2 presents an

example of multiple calculus that can occur on the same day and the need to integrate all these data to consider all variables when planning the offloading activities[5].

In this figure, each company is represented by a specific color, and information about the company appears in two columns. The first column shows the stock and balance volumes of the company on a particular date. The second column displays the production, loan, refund, and lifting volumes. These values are indicated by a plus or minus sign, which represents the operation carried out in the company's balance.

The Company Balance Volume (CBV) encapsulates the available oil volume for each company in the consortium on a given date. It is calculated considering Previous Day's Balance ($B_{DayBefore}$), Produced Volume (PV), Borrowed Volume (BV), Lent Volume (LV), Refund Received Volume (RRV), Sent Refund Volume (SRV), and Executed Lifting Volume (ELV). Eq. 3 consolidates transactional volumes to represent the company's available oil stock.

At the initial point of calculation, $B_{DayBefore}$ is equal to the company's existing stock. The inclusion of PV in the formula accounts for new oil production, BV and LV represent the volumes of oil borrowed and lent, respectively, while RRV and SRV account for the volumes of refunds received and sent. CBV is an indispensable metric for decision-making and planning in the O&G consortium, ensuring that each member accurately understands their available resources for operational activities.

$$CBV = B_{DayBefore} + PV + (BV - LV) + (RRV - SRV) - ELV \quad (3)$$

This complex management of loans and refunds, currently managed through manual data sheets, underscores a significant challenge in data coherence and accessibility. It is critical to have an integrated solution that covers all aspects of the lifting process, including schedule planning, execution, and even loans and refunds. By ensuring that all relevant data is cohesively integrated and easily accessible, the consortium can move towards a more efficient, transparent, and reliable operational framework, thereby enhancing overall effectiveness in the O&G sector.

[5]These data do not reflect the real data, only for example purposes.

5 OIL AND GAS BLOCKCHAIN NETWORK

5.1 Technical Infrastructure and Functionality

OGBN was built on the HF platform. This platform allows the creation of private channels, allowing subsets of network participants to engage in confidential transactions and data sharing. This feature is particularly beneficial in the O&G sector, where operations often involve business sensitive data and require selective disclosure among various stakeholders. The flexibility to establish private channels enables OGBN members to use a common infrastructure while maintaining the confidentiality and integrity of their individual operations. Figure 3 depicts the OGBN architecture.

This architecture illustrates that each participant possesses an instance of both the Peer and Orderer nodes. Peer nodes are responsible for maintaining the ledger and executing the smart contracts (known as chaincode in HF). These nodes enable consortium members to submit transactions, interact with the ledger, and ensure that their copy of the ledger is up-to-date and consistent with the network's state. The significance of Peer nodes lies in their ability to facilitate transparency and immutability, ensuring that all transactions and data within the OffloadingBR system are verifiable and trustworthy.

In contrast, Orderer nodes are essential for maintaining the overall health and consensus of the blockchain network. These nodes take on the responsibility of ordering transactions into blocks and distributing them to all Peer nodes in the network. The Orderer nodes ensure that transactions are processed in an orderly and efficient manner, thereby preventing potential conflicts and maintaining the integrity of the blockchain. This ordered sequence of transactions is critical in scenarios like offloading operations, where the accuracy and chronological order of transactions, such as lifting schedules and loan payments, are paramount.

Moreover, HF's capacity for creating private channels is particularly advantageous for OffloadingBR. It allows different consortia to engage in confidential transactions and data sharing, in a common infrastructure. This feature is crucial for managing the diverse and often confidential data involved in offloading operations, such as production volumes, lifting schedules, and financial transactions related to loans and refunds in different consortia.

Another significant benefit of HF is its scalability and performance efficiency. Given the volume of

			Company 1		Company 2		Company 3		Company 4		Company 5		Company 6	
Date	Available	Operations	Avail.	Op.	Avail.	Op.	Avail.	Op.	Avail.	Op.	Avail.	Op.	Avail.	Op.
Jan 31, 2023	stock balance	production refund lifting loan	-1.756,17 **5.243,83**	+341,46	5.121,93 **1.021,93**	+170,73	5.121,93 **2.221,93**	+170,73	2.560,95 **2.560,95**	+85,37	2.560,95 **2.560,95**	+85,37	4.390,41 **4.390,41**	+146,35
Feb 01, 2023	stock balance	production refund lifting loan	-1.414,71 **5.585,29**	+341,46	5.292,66 **1.192,66**	+170,73	5.292,66 **2.392,66**	+170,73	2.646,32 **2.646,32**	+85,37	2.646,32 **2.646,32**	+85,37	4.536,76 **4.536,76**	+146,35

Figure 2: Example of companies' balance.

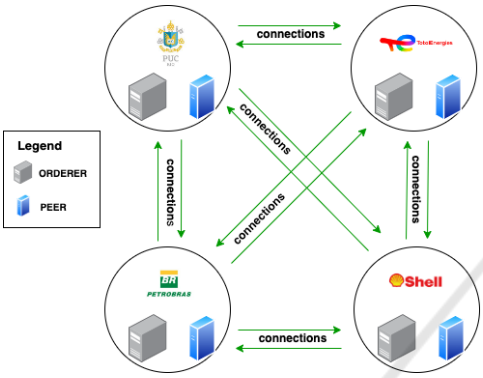

Figure 3: OGBN architecture.

transactions and the complexity of data in offloading operations, HF's ability to handle high transaction with minimal latency is key to maintaining operational efficiency. This ensures that OffloadingBR can operate smoothly under demanding conditions.

5.2 Applications and Potential Impact

The deployment of OGBN creates relevant opportunities for numerous applications, ranging from improving the efficiency of supply chain logistics to enhancing the transparency of transactions and operations. By providing a shared, yet secure and customizable platform, OGBN facilitates seamless data exchange and process coordination among its members. The potential impact of OGBN extends beyond operational efficiencies to include advancements in regulatory compliance, environmental monitoring, and resource optimization, thereby contributing to the overall sustainability and progress of the O&G sector.

OGBN already supports other applications in the O&G sector, such as BallotBR (Alves et al., 2022). The latter is a solution designed to support voting and communication actions in a consortium environment. The implementation of BallotBR within the OGBN ecosystem indicates the network's versatility and capacity to support a diverse range of blockchain applications, which includes the OffloadingBR solution.

Thus, in the context of the offloading use case within the O&G sector, a permissioned blockchain model is the most appropriate approach. This preference is rooted in the industry's unique requirements for confidentiality, control, and compliance. A permissioned blockchain, unlike its public counterpart, allows for selective access control, meaning that only authorized participants can join the network, which is crucial in the O&G industry.

Furthermore, the ability to enforce specific governance rules and protocols within a permissioned blockchain aligns with the industry's need for stringent regulatory adherence and operational consistency. This controlled environment not only fortifies security and trust among participants but also enables a more efficient and coordinated approach to offloading operations. By ensuring that each member adheres to the agreed-upon rules and processes, the permissioned blockchain model facilitates a harmonious and transparent operational framework.

6 LIMITATIONS

The proposed solution, while effective, encounters limitations in its integration with the Operator's Production Import System (SIP) and SAP systems. These systems are used to collect data from FPSO and manage invoices regarding the lifted oil, loans, and refunds. Currently, production data is manually imported using Excel sheets. Despite this limitation, once data is uploaded into the system, it adheres to a write-only protocol. This means any subsequent changes to the data are recorded, maintaining a historical record on the blockchain, ensuring data integrity and traceability.

Additionally, while the system has been primarily developed from the perspective of the Operator, who plays a central role in the offloading environment, it is also designed for use by non-operator companies. Thus, their participation and feedback are crucial, as they provide diverse insights and contribute to the system's continuous improvement, ensuring it meets the broader needs of all consortium members.

7 CONCLUSION AND FUTURE WORK

In conclusion, our study demonstrates the potential of blockchain technology in the O&G offloading activity. By enhancing transparency and efficiency, blockchain offers a transformative solution to long-standing challenges in this industry. Our findings suggest significant improvements in operational processes and management, which are manually made, laying the groundwork for more reliable and streamlined operations.

However, the adoption of this technology also presents limitations and challenges that warrant further investigation. This study serves as a stepping stone toward a broader discussion on technological advancements in the energy sector, underscoring the need for continuous innovation and adaptation. Moreover, integrating offloading data, which links oil production, lifting planning and execution, and loan and refund processes, marks a significant advance in digitalization and efficiency enhancement within the O&G industry.

In future work, we expect to perform qualitative studies and execute a Technology Acceptance Model (TAM) methodology to receive the non-operator partner's feedback structure. Finally, we aim to enhance the OffloadingBR data integration, connecting with SIP and SAP systems.

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