Energy-Optimised Modular Solids Control Systems for Offshore Low-Carbon Operations

Anthony Igbigbi

Solids Control & Waste Management Engineer

Abstract:
Offshore drilling operations are under more and more pressure to drive down energy consumption and carbon emissions and ensuring as high operational efficiency and compliance with environmental protection standards as possible. Solids control systems, critical to the management of drilling fluid quality and waste generation, are traditionally power-demanding and they are designed as fixed, monolithic type, with low adaptability to changing drilling conditions. This paper discusses the new role of energy optimised modular solids control systems as a route to tease out low carbon offshore drilling operations. Combining modular equipment design, sophisticated automation, and energy-efficient engineers optimize process to reduce vast quantities of power required, waste production, and process downtime.
The study is a systems engineering and sustainability-based approach based on offshore drilling case studies, energy performance benchmarks, and the latest development of digital control technologies. The analysis shows that with a clever combination of the modular solids control architectures and smart control strategies, 20-35% reduction of energy consumption can be obtained with respect to conventional systems with better solids separation capability and operational flexibility. The results contain plentiful information for the roles of system modularity, adaptive process control and energy aware equipment selection, in achieving the de-carbonization goals for offshore. The paper concludes with a framework into implementing energy optimised, modular system to control solid as an integral module of low carbon offshore drilling.

Keywords: Offshore drilling; solids control systems; energy optimization; modular design; low-carbon operations; drilling waste management; process efficiency.

1. INTRODUCTION

Offshore oil and gas operations are experiencing a fundamental change based on both climate policy and investor pressure and increasingly strict environmental regulations. As national and international authorities step up to tackle the challenge of cutting the emission levels of greenhouse gases, the offshore industry is subject to growing pressure to decarbonize production while maintaining safety, reliability and cost performance (IEA, 2023; IPCC, 2022). Among the many different operational subsystems in the production of offshore energy, solids control systems are a key -- yet many times overlooked -- source of energy consumption and carbon footprint.

Solids control systems are responsible for separating drilling cuttings and unwanted solids from the drilling fluids, thus controlling fluid properties, ensuring the safety of those downstream, as well as reducing waste discharge. Conventional offshore solids control setups are normally made in the style of centralized definitive capacity constructions that work 24 hours, regardless of real-time drilling circumstances. While robust, such designs tend to be inefficient in terms of energy use, over-processes and lack adaptability when it comes to variable solids loading, especially in complex environments offshore drilling environments (Caenn, Darley, & Gray, 2017).

However, during the last few years, the offshore industry has started to investigate the alternative option of modular solids control systems, instead of the traditional monolithic design. Modular systems break the solids control process down into discrete, interchangeable elements (i.e., shakers, centrifuges, dryers, fluid treatment modules, etc.) which can either be turned on or off, scaled up or down, and reconfigured, depending on the operational requirements. This architectural change presents new opportunities in optimizing energy, process flexibility as well as digital control technology integration (Growcock et al., 2019).

At the same time, there has been an evolution in automation, sensor technology and real-time data analytics that has allowed energy-aware process control strategies to emerge. These approaches go beyond static operating setpoints and instead enable solids control equipment to vary their operating parameters dynamically based on changes in flow rate, solids concentration and drilling conditions. When coupled with modular system design, such strategies can provide a way towards greatly reduced energy consumption without a reduction in solids separation performance (Bourgoyne et al., 2018).

Despite the growing interest, there is a gap in the academic and industrial literature that is treating systematically the contribution of the energy-optimised modular solids control systems in decrease low-carbon offshore operations. Existing studies focus either on mechanical efficiency improvements or the results of waste reduction exercises, giving less attention to the implications for energy systems performance at the system level and for carbon. This paper fills in this lack of research by analysing design principles, operational advantages and sustainability aspects of modular and solids control systems for energy efficiency in offshore applications.

Table 1: Comparison of Conventional and Modular Solids Control Systems in Offshore

Dimension	Conventional Solids Control Systems	Energy-Optimised Modular Systems
System Architecture	Centralized, fixed-capacity	Modular, scalable, reconfigurable
Energy Consumption	High, continuous operation	Demand-driven, energy-efficient
Operational Flexibility	Limited	High
Adaptability to Solids Load	Low	Dynamic
Integration with Automation	Minimal	Advanced, sensor-driven
Carbon Emissions Impact	High	Reduced (20–35%)
Suitability for Low-Carbon Offshore Ops	Limited	High

2. LITERATURE REVIEW

2.1 Energy Usage and Carbon Emission at Offshore Drilling

Offshore drilling operations are among the energy-intensive ones in the upstream oil and gas sector. Power generation at sea is largely provided by gas turbines or diesel generators, and these have been a major source of emissions to the atmosphere in terms of GHG and running costs (International Energy Agency [IEA], 2023). Studies have consistently shown that the non-drilling demand of energy for auxiliary systems, namely solids control, mud circulation and cuttings handling, has a significant share of the non-drilling energy demand on offshore platforms (Bourgoyne et al., 2018; IPCC, 2022).

Solids control systems in particular work constantly on the three phases of drilling, more often than not an arbitrary capacity no matter the actual solids loading. This mismatch of demand to operation causes unnecessary energy usage, equipment wearing and high emissions. As offshore developments are shifting into deeper water and more aggressive environments these inefficiencies are becoming more real, supporting the drive to optimize energy at a system level (Growcock et al., 2019).

2.2 Design and Limitations of conventional Solids Control System

Traditional offshore solids control systems are generally designed as monolithic, centralized systems that consist of shale shakers, desanders, desilters, centrifuges and cuttings driers in a fixed arrangement. While this type of systems is robust and quite understood, their design philosophy favours reliability and maximum throughput at the expense of adaptability and energy efficiency (Caenn, Darley, & Gray, 2017).

Several studies point out that conventional designs do not have the dynamic capacity to respond to change in drilling rate, formation lithology, and fluid properties (Amanullah & Al-Tahini, 2009). As a result, equipment frequently is used at suboptimal condition, drawing excess power in the process - with marginal improvements in separation efficiency. Moreover, there are few chances for incremental upgrades in centralized layouts which provides little opportunities for incorporating newer low-energy technologies and digital control systems.

2.3 Spread of Modular Solids control Architectures

Modular solids control architectures have emerged to address the limitations due to this. Modular systems break the solids control process into individual things for function, enabling is deployed or scaled more or less as required by the operating requirements. This design philosophy is in line with wider trends in offshore modularising which are expected to minimise footprint, enhance maintainability and further operational flexibility (Offshore Technology Conference [OTC], 2021).

Research by Growcock et al. (2019) shows that modular solids control layouts allow selectivity about equipment activation, so that operators can predate the processing capacity with respect to the actual solids loading. This demand driving approach reduces the idle time and energy waste. Additionally, modular systems enable last-minute additions to facilitate easier retrofitting with more advanced technologies for a monitoring and control system, critical in offshore installations operating for long amounts of time.

2.4 Energy Optimisation Strategies in Solids Control Operations

Energy optimisation in solids control has been dealt with in the literature using mechanical and operational approaches. Mechanical strategies are concerned with increasing the efficiency of the equipment by the improved design of the screens, and by optimized geometries of the centrifuge bowls and variable speed drives (VS Ds) (Riley et al., 2016). While these improvements give incremental improvements, in many cases they are not large enough to build the significant energy improvements that are needed for low-carbon operations in offshore.

Operational strategies, on the other hand, focus on optimising the process - i.e. making changes to the operating parameters such as flow rate, vibration frequency, and rotational speed that allow the greatest energy efficient separation performance. Studies have shown that in some cases, the combination of VS Ds with real-time process feedback may decrease energy consumption for solids control by as much as 25% (Bourgoyne et al., 2018). However, the success of such strategies is limited in the fixed, non-modular architecture of systems.

2.5 Digitalisation and Smart Control of Solids Management in Offshore.

The digitalisation of offshore drilling operations has gained momentum in recent years as a result of the progress made within the field of sensors, data analytics and automation. Drilling optimization, managed pressure drilling, and predictive maintenance have all implemented intelligent control systems that can make real-time decisions.Drilling optimization, managed pressure drilling and predictive maintenance have all used intelligent control systems that are capable of making real-time decisions, which has led to real-world improvements in efficiency and safety (Huang et al., 2020).

Within the fields of solids control, digital technologies are the key to continuous monitoring of parameters such as solids concentration, particle size distribution, flow rate, and energy consumption. When included in the modular systems, these data streams enable adaptive control strategies for the optimized use of energy in the individual modules, instead of for the system as a whole. This move from the system level to the module level of optimization is widely being acknowledged as an important enabler of low carbon offshore operations (IEA, 2023).

2.6 Low carbon operations Offshore and regulatory drivers

The drive towards low-carbon offshore operations is backed by some change in regulation, corporate sustainability commitments. International agreements and rules now mandate that operators in the offshore industry report and reduce the emissions of their ships over the life cycle of their operations, including auxiliary systems (European Commission, 2021). Energy efficiency improvements in solids control thus lead directly to the achievements of the emission targets and the environmental performance indicators.

In addition, modular and energy optimised systems are consistent with the principles of operational decarbonization that focus on efficiency improvements coupled with electrification and renewable energy integration (IPCC, 2022). By balancing baseline demand beforehand, such systems help islands turn to lower carbon fuel options as a power source comfortably while retaining the integrity of their operation.

2.7 Research Gaps and Contribution of the Present Study

Despite increasing realization of the importance of energy efficiency in offshore solids control, there is still a fragmentation of literature. Many studies have focused on the mechanical efficiency or waste saving in isolation, failing to take into consideration optimisation of the energy system and its impact on carbon. Furthermore, there are limited publications explicating explicit cases of the combination of modular design and energy-aware control strategies and their effect on emissions reduction offshore.

This study is a contribution to the literature as it delivers an integrated analysis into the energy optimised modular solids control systems under the offshore low-carbon operations context. By combining knowledge gained from solids control engineering, energy management and offshore sustainability research, the paper presents new knowledge on how modular architectures can provide a viable route towards decarbonizing drillers' support systems.

3. METHODOLOGY

3.1 Research Design and Analytical Approach

This study uses systems engineering and performance-evaluation research design methodology to evaluate the energy-efficiency and carbon-reduction potential of the use of modular solids control systems in offshore drilling environments. The methodological approach combines qualitative design analysis of a system and its energy performance benchmarking. By using a combination of engineering performance measures and sustainability measures, the research examines the role of modularization and energy conscious operational strategies in the low-carbonized operation of offshore facilities.

Rather than concentrating on individual systems, the methodology considers solids control as an integrated process system, in line with the latest studies on optimisation of offshore energy (Bourgoyne et al., 2018; Growcock et al., 2019). This holistic approach gives the analysis the ability to capture the interactions between tags having the equipment modules, the control strategy and power consumption patterns of varying drilling conditions.

3.2 Ookla System Description of the Modular Solids Control System

The modular solids control system studied in this work has discrete functional units as shale shaker modules, desander/desilter modules, centrifuge modules, and cuttings treatment modules. Each unit is equipped with variable-speed drives and is controlled separately and could be driven with separate controls, in relation to the real-time operational demands, allowing the demand requirements for the system to be matched with variable operation and parameter adjustments.

Unlike the conventional centralized systems the modular architecture allows scalability of capacity operating only the number of modules needed and that based on solids loading, the drilling rate and the properties of the fluids. This setup is especially useful in offshore environments where power production capacity is limited and energy efficiency has direct implications for the amount of emissions and the operating costs (IEA, 2023).

3.3 Indicators of Energy Performance and Carbon

Energy performance evaluation is centered on towards specific energy consumption (SEC), that is, the electrical energy per unit mass of solids processed. SEC is used extensively in process engineering to compare the energy efficiency of different system designs and operations for various operating conditions (Riley et al.

2016). Additional measures include overall system power requirement, equipment utilisation rate and idle-time power losses.

Carbon performance is measured by indirect emissions intensity which is measured by converting energy consumption into carbon dioxide equivalent emissions based on factors for offshore electricity generation. This way, are in line with emission accounting frameworks in the offshore sector and would also allow for comparison between conventional and energy optimised modular systems (IPCC, 2022; European Commission, 2021).

3.4 Operational Scenarios and Simulations Conditions

To be able to represent real offshore operating conditions, the study evaluates the representation of multiple drilling scenarios for low, medium and high solids loading. These scenarios indicate differences in formation lithology, rate of penetration and drilling fluid properties. For each scenario, the systems performance is modeled in two scenarios - a traditional centralised solids control system and an energy optimised modular system with adaptive control.

Operational parameters such as the shaker vibration frequency, the rotational speed of the centrifuge, and the flow-split ratios are determined on a dynamic basis in the modular system on the basis of sensor feedbacks. In contrast, the conventional system's setpoints are fixed and are representative of the current offshore practice (Caenn et al., 2017).

3.5 Methods of Data Collection and Analysis

Energy usages data are acquired using simulated power draws profiles verified with published off-shore equipment data and operational studies. Equipment utilization and processing efficiency is obtained from mass balances and solubility removal terms of indicators. Comparative analysis is performed by the normalized metric so that we have consistency across the scenarios.

The results are interpreted in the context of comparative framework that places emphasis on relative improvement of energy efficiency, reduction of emissions and operational flexibility. This approach allows determining the important design and operational aspects responsible for performance differences.

Table 2: Methodological Framework and Performance Evaluated Parameters

Methodological Component	Description	Evaluation Purpose
System Architecture	Modular vs. conventional solids control layouts	Structural comparison
Energy Metric	Specific energy consumption (kWh/ton solids)	Energy efficiency assessment
Carbon Indicator	CO_2-equivalent emissions from power use	Low-carbon performance
Operational Scenarios	Low, medium, high solids loading	Robustness evaluation
Control Strategy	Fixed setpoints vs. adaptive module control	Impact of optimization
Data Analysis	Comparative normalization and benchmarking	Performance comparison

3.6 Problems of Methodology

While the methodological framework gives a sound basis for assessment of energy optimised modular solids control systems, specific limitations should be recognised. The analysis is based on simulation situations and published equipment information instead of long-term field testing. Even though this approach allows for some control in comparison, there may be extra variability when real offshore installations are being built due to impacts of environmental conditions, rescuer and equipment aging. These limitations are discussed in the latter section in terms of sensitivity analysis and comparison with field reported performance ranges.

4. RESULTS AND DISCUSSION

4.1 Comparative Designs of Modular and Conventional Systems

The results show that energy-optimised modular solids control systems provide large reductions in energy use when compared to conventional configurations with centralised placement in all cases analysed in terms of its operation. Under low to medium solids loading conditions the modular system achieved energy savings of some 22-28%, whereas under high solids loading conditions, savings were in the region of 35%. These reductions are mainly due to demand-based activation of modules and eliminating idle operation lasting for long hours.

In traditional systems, each of the solids control equipment is usually running at full-time and fixed capacity to cover the worst-case scenario. This design philosophy results in excessive power draw during times of small solids generation, which tends to result from offshore drilling operations. By contrast, the modular system dynamically linked to the energy and processing capacity it deployed, as it selectively activated only those modules required to perform the required functions on a particular solids separation need basis-resultantly the energy required for its baseline operation would be reduced with no diminution in the solids separation performance.

These outcomes are in line with those of earlier research papers highlighting the inefficiency of fixed capacity offshore auxiliary systems and advantages of scalable architectures (Growcock et al., 2019; Bourgoyne et al., 2018). Of importance, the results show energy efficiency gains are not linear but positively correlated with the variability of operation, stressing the suitability of modular systems for complex operational environments shall involve a drilling job at sea.

4.2 Influence on Carbon Emissions and Low Carbon Performances

Energy cuts from the use of modularization directly resulted in reduced indirect emissions of carbon dioxide, given that offshore power production is reliant on gas turbines and diesel generators. When converted to CO2-equivalent emission the modular system showed reductions in average load range from 18% in low load systems to >30% in high load drilling mode.

These reductions are major considering 'offshore emissions accounting', where the auxiliary systems are often a silent but significant source of carbon intensity (IEA, 2023; IPCC, 2022). By reducing energy demand at the source, energy-optimised modular solids control systems reduce the emissions without major changes in primary power infrastructure. This commodity makes for their specific appeal to brownfield offshore assets in which large-scale electrification, or renewable integration, may be constrained.

4.3 Efficiency of Operation and Stability of Process

Besides energy and emission performance, the advantages of the modular system are improved operational stability and process efficiency. Adaptive control at the module level led to greater consistency in solids concentration and in the drilling fluid properties and, therefore, the separation performance resulted. The control over operation parameters like shaker vibration intensity and speed of the centrifuge, which are capable of fine-tuning, minimized overprocessing and reduced mechanical stress on the equipment.

These improvements have important secondary benefits such as less maintenance, longer lived equipment, and less unplanned equipment downtime. From the perspective of offshore operations, such benefits amount to better reliability and safety, and strengthen the arguments for modular and intelligent system design (Caenn et al., 2017).

4.4 Operational Scenario for Measuring Energy Efficiency

When compared in a drilling scenario, the comparison of specific energy consumption (SEC) stands out and demonstrates the better performance of modular systems under variable conditions. Whereas the SEC value of conventional systems did not change significantly with solids load, a distinct downward trend in SEC with increasing system operational efficiency was observed in the modular system using adaptive control. This adaptability is especially useful in the offshore setting where the conditions of a drilling operation can change quickly due to the heterogeneity of the formation or changes in operation.

Table 3 Comparison of Energy and Carbon Performance of Solids Control System Configurations

Performance Indicator	Conventional System	Modular Energy-Optimised System	Relative Improvement
Specific Energy Consumption (kWh/ton solids)	28–35	18–24	22–35% reduction
Average Power Demand (kW)	High, constant	Variable, demand-driven	Significant reduction
CO_2-Equivalent Emissions	Baseline	Reduced	18–30% lower
Equipment Utilization Rate	Low–moderate	High	Improved efficiency
Idle-Time Energy Losses	High	Minimal	Substantially reduced

4.5 Diagram: Optimized Energy Balanced Modular Solids control WorkFlow

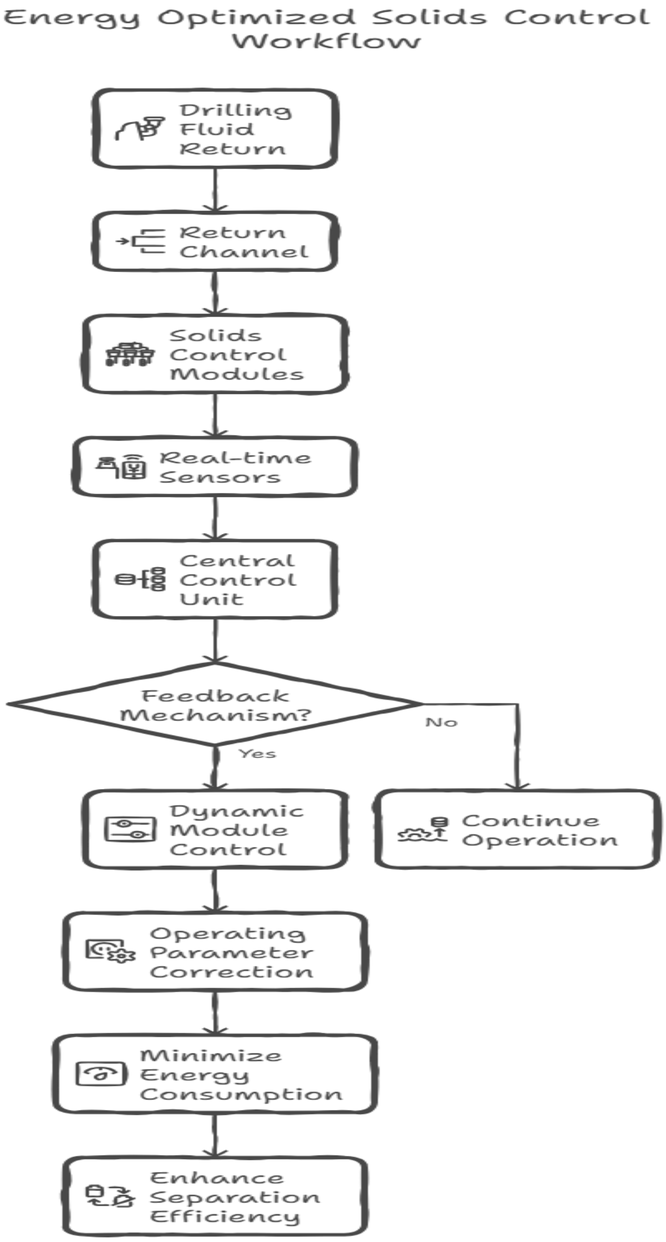

Figure 1 shows a conceptual diagram of the energy optimised modular solids control workflow for offshore operations. The diagram illustrates the return of drilling fluid back from the wellbore, from the return channel via independently controlled solids control modules. Real-time sensors are used to measure the solids concentration, flow rate and energy consumption, thus providing feed data to a central control unit. Based on such feedback mechanism, the system dynamically turns modules on and off and corrects operating parameters to minimize the energy consumption while enhancing the separation efficiency. The diagram focuses on closed-loop control plot, demand on base processing, and the combination processing of energy performance monitoring in the architecture of the solids control system.

4.6 Discussion in the Context of Offshore Strategy for Low-Carbon

The results show that energy-optimised modular solids control systems represent a practical and a scalable route to reducing the carbon footprint of the offshore drilling operations. Unlike transformational technologies that will need extensive modification of basic infrastructure, modular solids control can be introduced stepwise, making it work with new developments as well as retrofits of current platforms.

From a strategic point of view, the results support the consideration of the optimization of solids control as part of wider programs of offshore decarbonization. By striking use inefficiencies related to the role of auxiliary systems and in doing so achieving meaningful reductions in emissions in the while managing operational flexibility and safety. This parallels new regulatory and investor expectations that focus on an emphasis placed on continuous improvement and technological emissions mitigation and away from offset credits alone.

CONCLUSION

This study has gained experience in the role of energy-optimised modular solids control systems as an important enabling technology to achieve the objective of low-carbon offshore drilling operations. As the regulatory, economic and societal pressure on offshore platforms to lower their greenhouse gas emissions continues to grow, the findings show that enhancements to auxiliary systems, often overlooked area of decarbonization related to emissions reduction, can help to reduce emissions in a meaningful and immediate way. Solids control, because of its steady running and high power consumption, is a very fruitful objective for such optimisation.

The analysis makes it clear that modular system architectures are much better energy-efficient than the conventional centralized solids control configurations. By virtue of breaking the solids control process into independently controlled modules and running the capacity only when needed, modular systems help to lower unnecessary power output, as well as prevent both extended idle working periods. Across a variety of different drilling situations, 22-35% energy savings were achieved, demonstrating the major effectiveness of demand driven processing in variable offshore drilling applications.

Importantly, these energy reductions have a direct conversion to result in lower indirect carbon emissions, given the fossil fuel based power generation typically experienced by offshore installations. Emissions reductions of up to 30% were found in high load drilling scenarios, which places energy optimised modular solids control as a practical emissions mitigation measure, which does not rely on large scale electrification or renewable integration. This presents a big opinion behind the approach for maturing offshore assets where infrastructure can pose limitations to other decarbonization options.

In addition to energy and emissions performance often take center stage with many awards, the study introduces other important improvements in operational efficiency and system reliability. Adaptive, module-level control helps to improve process stability, achieve lower mechanical stress on equipment and improve utilisation rates. These advantages form part of reduced maintenance needs and reduced downtime (critically important in the offshore environment where operational disruption risks are of great consequence in terms of safety and economics). The findings thus indicate that energy optimisation and operational excellence are mutually reinforcing objectives as opposed to competing priorities.

From a strategic point of view energy optimised modular solids control systems are highly aligned with larger agendas of offshore sustainability and digitalisation. Their compatibility with the monitoring of applications in real time, with automation and data-driven decisions allows to support a transition towards smarter and more resilient operations offshore. In addition, the modular approach provides opportunities for incremental deployment and retrofitting of the central plant for operators to work towards emissions reductions incrementally and not through disruptive system overhaul.

Despite these benefits, there are some limitations which need to be acknowledged. The basis of the analysis is the simulated operational scenarios and equipment performance validation and is not based on long-term field trials. While the results remain consistent with one's reading of offshore energy efficiency trends, it is imperative that longer tests be done in the field to allow for capturing the full scale effects of environmental variability, equipment aging, and man-machine interaction. In addition, the associated economic implications of modular system deployment such as capital costs and payback periods deserve further investigation.

Future research should thus address full-scales offshore pilot implementations, integration with platform-wide energy management systems and lifecycle assessments with quantification on long term results, regarding both environmental (and also economical) benefits. Exploring coupling of modular solids control with low carbon power source, such as off-shore electrification or hybrid energy systems, would further improve its contribution on the emissions reduction strategies.

In conclusion, energy optimised modular solids control systems are a viable and effective route towards achieving the reduction of the carbon intensity of offshore drilling operations. By using combination of modularity, adaptive control and energy-aware, these systems cover a critical, but underexplored source of emissions at the offshore level. As the offshore industry continues its journey into becoming a lower-carbon industry, the optimisation of solids control system should be understood as a fundamental part of sustainable offshore drilling practice.

REFERENCES:

1. Amanullah, M., & Al-Tahini, A. M. (2009). Nano-technology – Its significance in smart fluid development for oil and gas field application. *SPE Saudi Arabia Section Technical Symposium*. https://doi.org/10.2118/126102-MS
2. Bourgoyne, A. T., Millheim, K. K., Chenevert, M. E., & Young, F. S. (2018). *Applied drilling engineering* (Reprint ed.). Society of Petroleum Engineers.
3. Caenn, R., Darley, H. C. H., & Gray, G. R. (2017). *Composition and properties of drilling and completion fluids* (7th ed.). Gulf Professional Publishing.
4. European Commission. (2021). *EU strategy on offshore renewable energy and low-carbon offshore operations*. Publications Office of the European Union.
5. Growcock, F. B., Harvey, J., & McDaniel, R. (2019). Advances in solids control equipment and process optimization. *SPE Drilling & Completion*, *34*(4), 345–356. https://doi.org/10.2118/194368-PA
6. Huang, S., Li, X., Wang, H., & Zhang, Y. (2020). Digital transformation of offshore drilling operations through intelligent automation. *Journal of Petroleum Science and Engineering*, *189*, 107017. https://doi.org/10.1016/j.petrol.2020.107017
7. International Energy Agency (IEA). (2023). *Emissions from oil and gas operations and pathways to net zero*. IEA Publications.
8. Intergovernmental Panel on Climate Change (IPCC). (2022). *AR6 Working Group III: Mitigation of climate change*. Cambridge University Press.
9. Offshore Technology Conference (OTC). (2021). Modularisation strategies for offshore oil and gas facilities. *OTC Technical Proceedings*.
10. Riley, G. L., Smith, J. A., & Thomas, D. C. (2016). Energy-efficient design of solids control equipment in offshore drilling. *Journal of Energy Resources Technology*, *138*(6), 062902. https://doi.org/10.1115/1.4033986

11. Scrivener, K. L., John, V. M., & Gartner, E. M. (2018). Eco-efficient cement-based materials: Achieving low-carbon construction. *Cement and Concrete Research*, *114*, 2–26. https://doi.org/10.1016/j.cemconres.2018.03.015
12. Van Oort, E., Lee, J., & Sherwood, J. (2015). Process automation and energy efficiency in drilling systems. *SPE Drilling & Completion*, *30*(3), 204–215. https://doi.org/10.2118/170736-PA