World Journal of Advanced Engineering Technology and Sciences

eISSN: 2582-8266

Cross Ref DOI: 10.30574/wjaets

Journal homepage: https://wjaets.com/

(REVIEW ARTICLE)

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# Aligning drilling fluid chemical LCA with regulatory standards – challenges and implications for oilfield operations

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World Journal of Advanced Engineering Technology and Sciences, 2025, 15(03), 2246-2248

Publication History**:** Received on 07 April 2025, revised On 15 April 2025; accepted on 23 April 2025

Article DOI: https://doi.org/10.30574/wjaets.2025.15.3.0797

## Abstract

As oil and gas operations confront growing regulatory demands, the life cycle assessment (LCA) of drilling fluid chemicals has emerged as a key sustainability tool. While global standards such as ISO 14040 and ISO 14044 provide foundational LCA frameworks, inconsistencies in their interpretation across regions introduce complexity and ambiguity in real-world application. This paper explores these discrepancies with a focus on water-based mud systems, assessing how boundary definitions, regional energy mixes, and variable disclosure practices influence calculated environmental impacts. Through a comparative study of differing regional methodologies, the paper illustrates how regulatory divergence can alter procurement and operational decisions.

**Keywords:** Life Cycle; US Regulations; Water based mud; Sustainability; EU Regulations

## 1. Introduction

Drilling operations rely heavily on chemical products that are consumed rapidly and in large volumes. While their lifecycle is short, the cumulative environmental impact of these chemicals can be significant. Regulatory frameworks around sustainability have prompted oil and gas companies to adopt life cycle assessment methodologies to evaluate environmental performance. However, the application of these methodologies is far from uniform.

Standards such as ISO 14040 (ISO, 2006a) and ISO 14044 (ISO, 2006b) offer guiding principles, yet regional frameworks such as the European Union Taxonomy for sustainable activities (European Commission, 2021) and chemical substance regulations from the United States Environmental Protection Agency (US EPA, 2022) often diverge in interpretation. This inconsistency has led to confusion during both internal reporting and external procurement evaluations.

## 2. Methodology

This study examines the life cycle emissions of a representative water-based drilling fluid, composed of clay-based viscosifiers, salts, and biological polymers. A cradle-to-gate system boundary was applied, including stages from raw material extraction to chemical packaging.

The methodology employed a standardized functional unit of one cubic meter of drilling fluid, with greenhouse gas emissions evaluated over an extended time horizon. Background data was derived from a mix of commercial life cycle inventory datasets and supplier environmental product declarations, with midpoint impact modeling carried out using a recognized LCA software platform.

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To account for regulatory variation, three regionally distinct assessments were performed

- One based on European guidance aligned with the Product Environmental Footprint Category Rules for chemicals
- One based on US environmental disclosure frameworks
- One based on ISO guidance applied in a neutral context

## 3. Discussion

### 3.1. Influence of Regulatory Interpretation

The European approach emphasizes strict inclusion of downstream transportation and mandates renewable energy disclosures. As a result, LCA values derived under this framework tended to be higher, especially for additives involving long-distance logistics or energy-intensive processes. In contrast, the US approach under TSCA encourages transparency but does not mandate full cradle-to-gate assessments or enforce uniform boundary conditions (US EPA, 2022).

An ISO-centric implementation often sits in the middle of these two extremes, leaving considerable discretion to the practitioner. For instance, while ISO encourages inclusion of upstream processes, it does not clearly prescribe treatment of capital goods or shared infrastructure, resulting in material variation between studies (Guinée et al., 2002).

### 3.2. Unintended Consequences in Reporting

Different boundary conditions produce significant shifts in reported carbon intensity. For example, the same clay-based viscosifier can have markedly different footprints depending on whether energy consumption includes regional grid mixes or renewable offsets. Additionally, some suppliers report emissions excluding storage and packaging stages, while others include these phases comprehensively.

This inconsistency creates substantial risk for misinterpretation when such data are used for internal dashboards or supplier comparison in tendering.

### 3.3. Gaps in Midpoint and Endpoint Indicators

Most LCA reporting in oil and gas focuses almost exclusively on global warming potential. However, regulatory bodies are beginning to call for inclusion of broader impact categories such as acidification, eutrophication, and water depletion (Smith et al., 2001). Emerging standards such as ISO 14008 also advocate for the monetization of these externalities, which could introduce further complexity into chemical selection processes (ISO, 2019).

## 4. Case Study: Water-Based Mud Under Divergent Frameworks

A common formulation consisting of mineral-based viscosifiers, a potassium salt, and organic fluid-loss reducers was evaluated under each of the three regional methodologies. While the composition remained constant, reported environmental impact varied depending on

- The scope of transport emissions
- The treatment of energy origin
- Inclusion or exclusion of packaging
- Allocation choices for by-products in supply chains

These methodological differences shifted supplier ranking significantly when the results were used in procurement evaluations. In one instance, a supplier initially ranked lowest in terms of environmental performance moved to the top after methodological normalization, solely due to a more conservative initial boundary definition.

## 5. Conclusion

Without harmonization, the application of LCA to drilling fluid chemicals remains fraught with inconsistency. Regulatory interpretation plays a decisive role in shaping reported carbon intensities. For oil and gas operators, this variability undermines the comparability and utility of LCA data in procurement and sustainability reporting.

To bridge the gap, industry must advocate for

- Clearer guidance on boundary conditions
- Cross-regional standardization efforts
- Broader adoption of midpoint indicators

Until such progress is made, practitioners must tread carefully in applying LCA data across jurisdictions.

promoting CCUS as a climate mitigation strategy.

## Compliance with ethical standards

*Disclosure of conflict of interest*

No Conflict of interest to be disclosed. It has been presented at 2025 Green Technology Conference.

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