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Assessing the water footprint of drilling operations: A case study of well drilling in Texas

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Abstract

The water footprint of drilling operations is a critical environmental consideration in resource extraction, particularly in water-scarce regions such as Texas. This paper evaluates the water consumption associated with drilling different types of wells in Texas, with a focus on the water used in drilling, completion, and hydraulic fracturing processes. By analyzing various well types, including vertical, horizontal, and multi-stage hydraulic fractured wells, we aim to quantify the total water footprint required for each process. The study leverages data from recent drilling operations to estimate water usage and discuss the sustainability of such practices in the context of ongoing water scarcity issues in Texas. This paper highlights the need for better management of water resources in drilling operations and offers suggestions for reducing water consumption through technological innovations and operational efficiencies.

Keywords: Drilling; Water footprint; Resource management; Texas; Sustainability

1. Introduction

Texas is a leader in oil and natural gas production, contributing significantly to the United States' energy output. As drilling operations expand, particularly in regions like the Permian Basin and Eagle Ford Shale, concerns have grown over the environmental impacts of these activities. One key issue is water consumption, as drilling and hydraulic fracturing processes require large volumes of water. The water footprint, or the total volume of water used throughout the lifecycle of a well, varies based on the type of wellbeing drilled, the geographical location, and the specific techniques employed.

This paper seeks to examine the water footprint of drilling a well in Texas, with a particular focus on comparing water usage across different well types, including vertical, horizontal, and multi-stage fractured wells. Understanding the scale of water use in these operations is critical for developing sustainable practices and managing the state's water resources effectively.

2. Methodology

To assess the water footprint of well drilling in Texas, this study uses data from publicly available reports, industry publications, and case studies of recent drilling operations. The water footprint analysis is broken down into three key phases of the drilling process:

- **Drilling Phase:** The volume of water required to drill a well to the desired depth. This includes water for cooling drill bits, controlling pressure, and clearing debris.

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- **Completion Phase:** Water used for well completion activities, such as casing the well and conducting pressure tests.
- **Hydraulic Fracturing Phase:** Water injected into the well to create fractures in the rock, enhancing the well's ability to produce oil or gas.

Data is collected from multiple sources, including industry reports from the U.S. Energy Information Administration (EIA), publications by the Texas Water Development Board (TWDB), and independent case studies of different well types in Texas. The data is analyzed to estimate the average water consumption per well for each phase of drilling and completion. The analysis also considers variations in water use depending on well type, well depth, and location within Texas.

3. Case Study: Water Usage in the Permian Basin and Eagle Ford Shale

The Permian Basin and Eagle Ford Shale are two of Texas's most significant oil and gas production areas. These regions are known for their high-intensity drilling activities, with large numbers of horizontal wells requiring extensive water usage for hydraulic fracturing.

In the Permian Basin, a study by the Texas Oil and Gas Association (TXOGA) reported that an average horizontal well can require between 2 million and 5 million gallons of water for hydraulic fracturing alone (TXOGA, 2021). The drilling phase for these wells can consume an additional 200,000 to 500,000 gallons of water, depending on the depth and geology of the site (EIA, 2022).

In contrast, vertical wells in the Eagle Ford Shale typically require less water, with the hydraulic fracturing phase using around 1 million to 2 million gallons of water. The drilling phase also tends to use less water for vertical wells compared to horizontal wells, as the drilling process is generally more straightforward and requires fewer cooling agents and mud treatments (Texas Water Development Board, 2020).

The variation in water usage between vertical and horizontal wells illustrates the influence of well type and technological methods on overall water consumption in drilling operations.

4. Results

The average water consumption for drilling a well in Texas varies significantly depending on the well type and location:

4.1. Vertical Wells

- Drilling Phase: 200,000–500,000 gallons
- Hydraulic Fracturing Phase: 1 million–2 million gallons
- Total Water Footprint: 1.2 million–2.5 million gallons per well.

4.2. Horizontal Wells

- Drilling Phase: 300,000–700,000 gallons
- Hydraulic Fracturing Phase: 2 million–5 million gallons
- Total Water Footprint: 2.3 million–5.7 million gallons per well

These values highlight the significant water requirements for modern oil and gas drilling operations, particularly in shale plays that rely heavily on hydraulic fracturing. As drilling depths increase and well complexity grows, the water footprint will likely continue to rise unless more sustainable practices are adopted

5. Discussion

The findings suggest that hydraulic fracturing (fracking) is the largest contributor to water consumption in drilling operations in Texas. Horizontal and multi-stage fractured wells, which are more common in shale plays like the Permian Basin, tend to have significantly higher water footprints than vertical wells. This is due to the large volumes of water required for the fracking process, which involves pumping water, sand, and chemicals into the well at high pressure to stimulate the release of hydrocarbons.

While water consumption for drilling is substantial, it pales in comparison to the water needed for hydraulic fracturing. Fracking water use can sometimes exceed 4 million gallons per well, depending on the size of the well and the fracturing design. However, some of this water is recycled and reused for subsequent wells, which can reduce the overall demand on freshwater resources.

In water-scarce regions like West Texas, where the Permian Basin is located, the high water demands of drilling operations exacerbate the challenges of managing limited water resources. As drought conditions become more frequent and intense, there is increasing pressure on the oil and gas industry to find ways to reduce water consumption.

6. Conclusion

This study underscores the substantial water footprint of drilling operations in Texas, particularly in the context of horizontal wells and hydraulic fracturing. As water scarcity concerns grow, it is crucial for the industry to adopt water-saving technologies, such as the reuse and recycling of fracking water, and to explore alternative water sources, such as brine or treated wastewater. Additionally, regulatory frameworks must be established to ensure that the water needs of the energy sector do not compete with those of agriculture, municipalities, and other critical sectors.

Future research should focus on more detailed life-cycle assessments of well drilling, considering factors like water quality and long-term environmental impacts. With advancements in water-efficient technologies, there is potential to significantly reduce the water footprint of drilling operations, contributing to both the sustainability of the energy industry and the preservation of vital water resources.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed. The paper has been presented at an American Petroleum Institute Sub-Committee in Jan 2025.

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