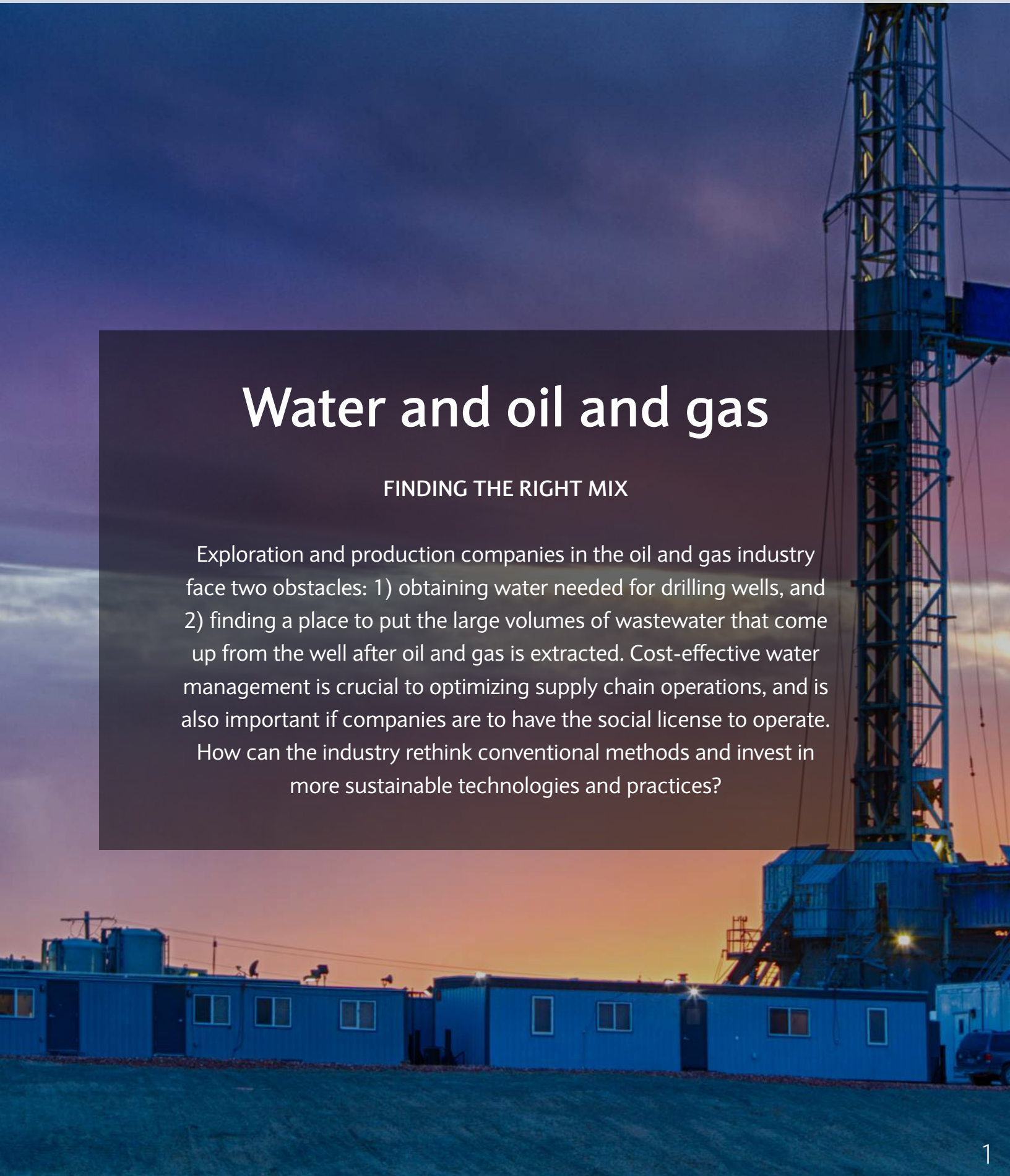


Water and oil and gas

FINDING THE RIGHT MIX

Exploration and production companies in the oil and gas industry face two obstacles: 1) obtaining water needed for drilling wells, and 2) finding a place to put the large volumes of wastewater that come up from the well after oil and gas is extracted. Cost-effective water management is crucial to optimizing supply chain operations, and is also important if companies are to have the social license to operate. How can the industry rethink conventional methods and invest in more sustainable technologies and practices?

A water-intensive industry

The process of hydraulic fracturing (fracking) used in oil and gas drilling poses unique water challenges and threats to the environment. The industry must treat the large amounts of water fracking requires – and the wastewater it creates – as the precious resource it is.

THE CHALLENGE

Oil and gas operations have become more water-intensive

Wastewater disposal poses environmental stresses

Water scarcity drives up the price of freshwater

THE MANDATE

Rethink water acquisition and disposal

Invest in more sustainable practices

Increase water reuse

THE OPPORTUNITY

Turn recycled water into a new resource for other industries

Increase sustainability of the environment, society and industry

Reduce ongoing water costs

New oil wells, new water demands

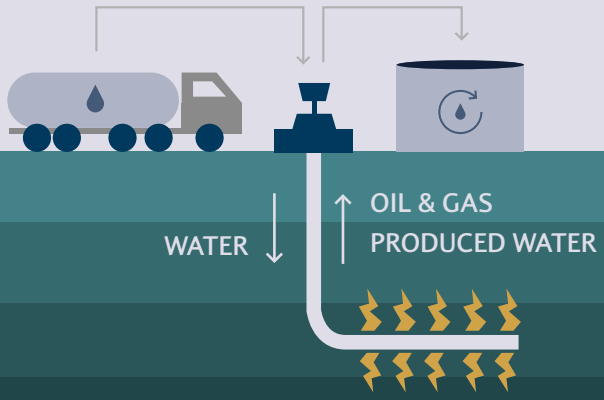
While water use varies by play and region, overall, it has been rising since 2008. Much of this increase can be attributed to a shift from vertical to horizontal wells. Horizontal drilling improves production efficiencies and reduces the number of wells drilled overall, but is also more water-intensive than vertical drilling.

VERTICAL

Conventional drilling directly to oil

Requires less water overall

HORIZONTAL



Reaches wider area of rock and oil/gas trapped within

High-pressure water needed to break rock and release hydrocarbons

Requires more water overall

Source: EPA

INCREASE IN FRESHWATER USED FOR INJECTION STAGE IN HYDRAULIC FRACTURING

5,618
barrels of water

2008

128,102
barrels of water per oil well

2014

162,906
barrels of water per gas well

= 5,000

Source: USGS

Mapping water stress in the U.S.

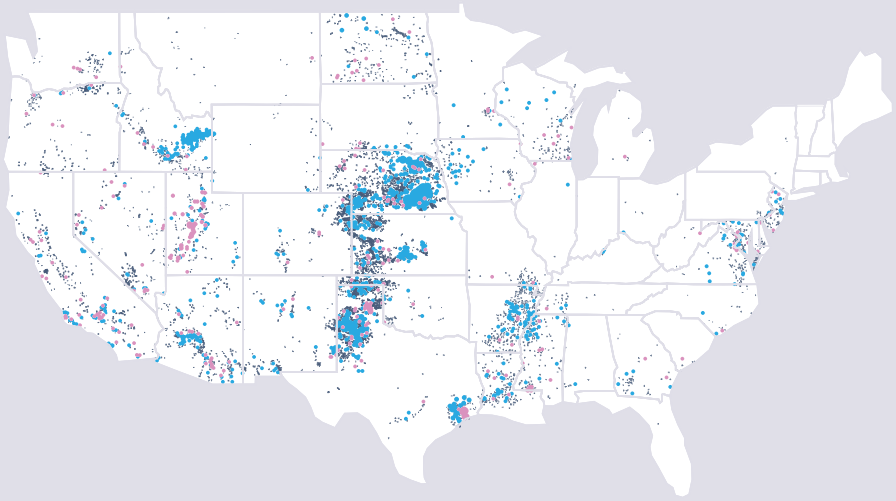
Water maps of the United States dramatize the wide variations in water supply, including the impacts of water withdrawals and climate-driven drought. Brackish water is unsuitable for human consumption without treatment, and may require additional treatment before use by some industries.

Groundwater Stress

This map illustrates the locations of wells where groundwater extraction is increasing, while replenishment is happening at a much slower rate.

Well location

- Wells where groundwater change is driven by agriculture.
- Wells where groundwater change is driven by other activities.
- Location of all other wells.



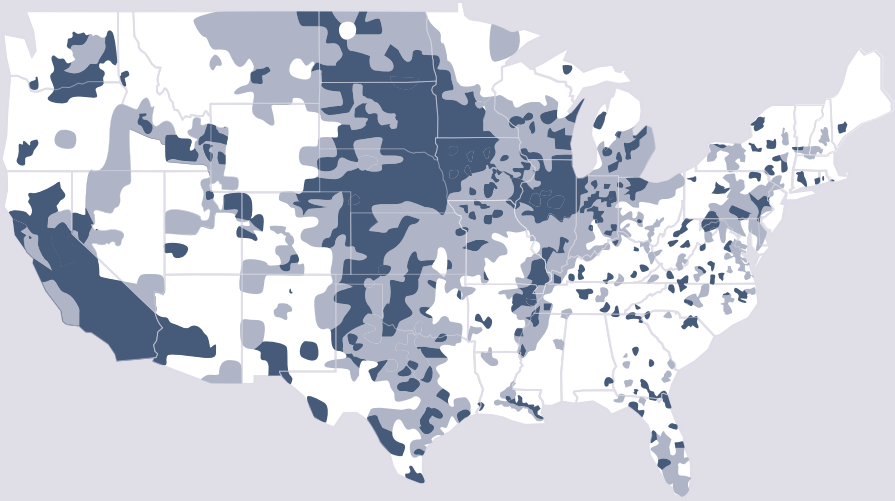
Source: Ho, M., V. Parthasarathy, E. Etienne, T. A. Russo, N. Devineni, and U. Lall (2016), America's water: Agricultural water demands and the response of groundwater, Geophys. Res. Lett., 43, 7546–7555, doi:10.1002/2016GL069797

Drought

This map illustrates water stress based on multi-year cumulative droughts from 1949-2009. Shades of blue represent water usage driven by human activity exceeding what is supplied by rainfall.

Drought risk driven by human activity

- Low
- Medium
- High



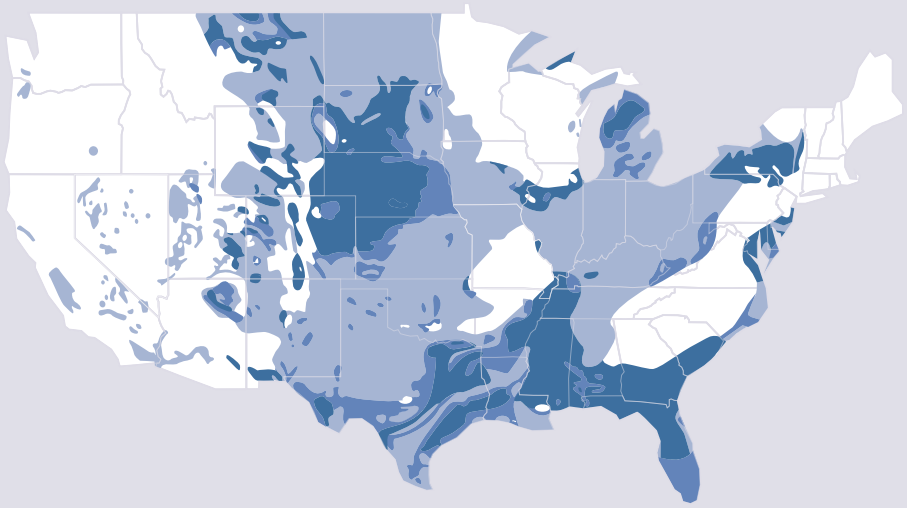
Source: Devineni, N., U. Lall, E. Etienne, D. Shi, and C. Xi (2015), America's water risk: Current demand and climate variability, Geophys. Res. Lett., 42, doi:10.1002/ 2015GL063487

Brackish Water

This map shows presence of brackish water, which has more salinity than freshwater, but less than seawater. Brackish water can be treated and used for drinking water and by many industries.

Depth to saline (including brackish)* goundwater, in feet

- Less than 500
- 500 to 1,000
- Greater than 1,000
- Inadequate information

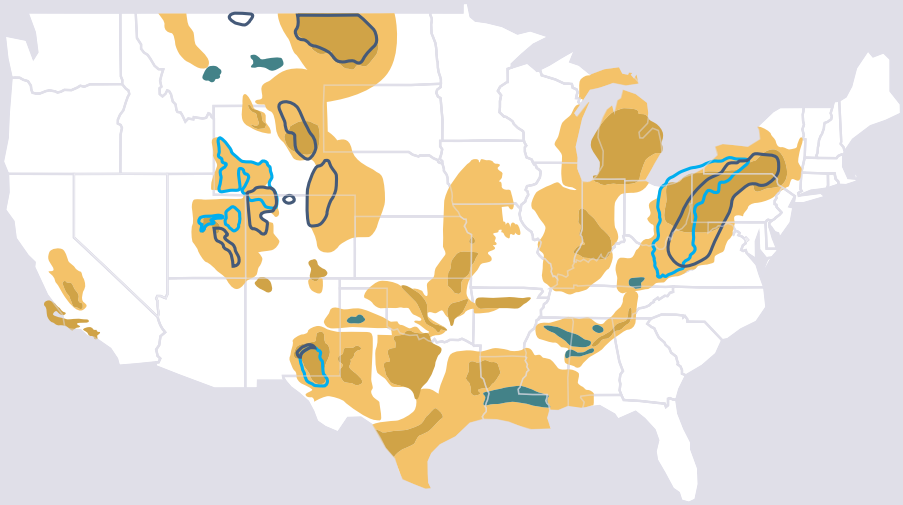


Source: USGS

Lower 48 States Shale Plays

This map shows the oil and gas basins throughout the U.S. as of 2016 — regions where the oil and gas industry is drilling today, and in the future.

- Current play – oldest stacked play
- Current play – intermediate depth/age stacked play
- Current play – shallowest / youngest depth/ age stacked play
- Prospective play
- Basin

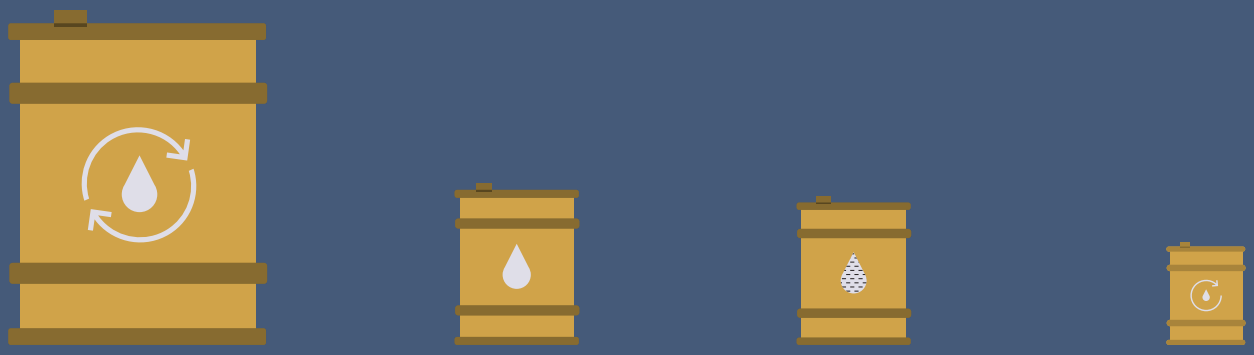


Source: U.S. Energy Information Administration based on data from various published studies Updated: June 2016

Putting a price on a barrel

The average cost of a barrel of water varies by type, but it becomes dramatically cheaper when water is reused. A by-product of oil and gas drilling, "produced" water can save oil and gas companies money, and we project that the market for produced water will grow to $3.26 billion by 2021. Technological improvements are still needed for recycling (which is more energy-intensive than reuse) to be cost competitive.

AVERAGE WATER COSTS FOR OIL AND GAS COMPLETIONS IN THE PERMIAN



$2.50	$0.50	$0.45	$0.27
Recycled	Fresh	Brackish	Reused

BOTTOM LINE

By moving to reused wastewater, the industry could:

Lower water acquisition costs by

45%

Save over

300k

Barrels per well

GLOSSARY

Freshwater is deemed safe for human consumption, occurring naturally through precipitation, and in dams, rivers and some underground sources.

Brackish water is a naturally occurring mixture of fresh and salt water, also known as brine.

Saline occurs naturally in oceans, has a salt content higher than brackish water, and is not drinkable.

Recycled water is wastewater that has undergone a robust treatment in order to be used again.

Reused water is wastewater reused within an oil or gas well, requiring little or no treatment.

4 water trends impacting oil and gas

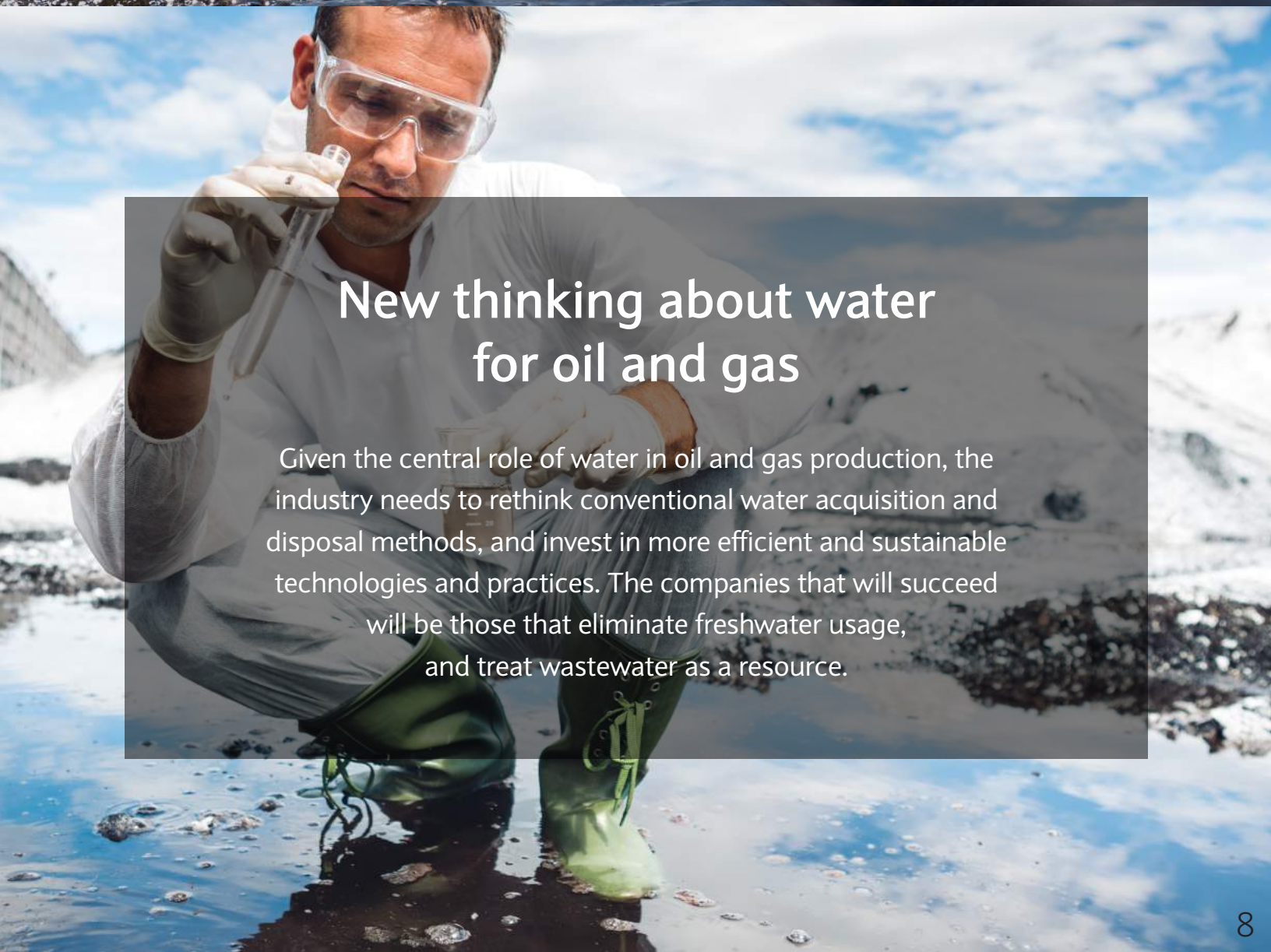
The industry faces unique regulatory constraints for water disposal and acquisition. Among other trends, continued public concern and scrutiny around lack of sustainable water practices could lead to state regulation, potentially impacting water-handling operations.

Regulations

Public awareness

Security

Cost-cutting

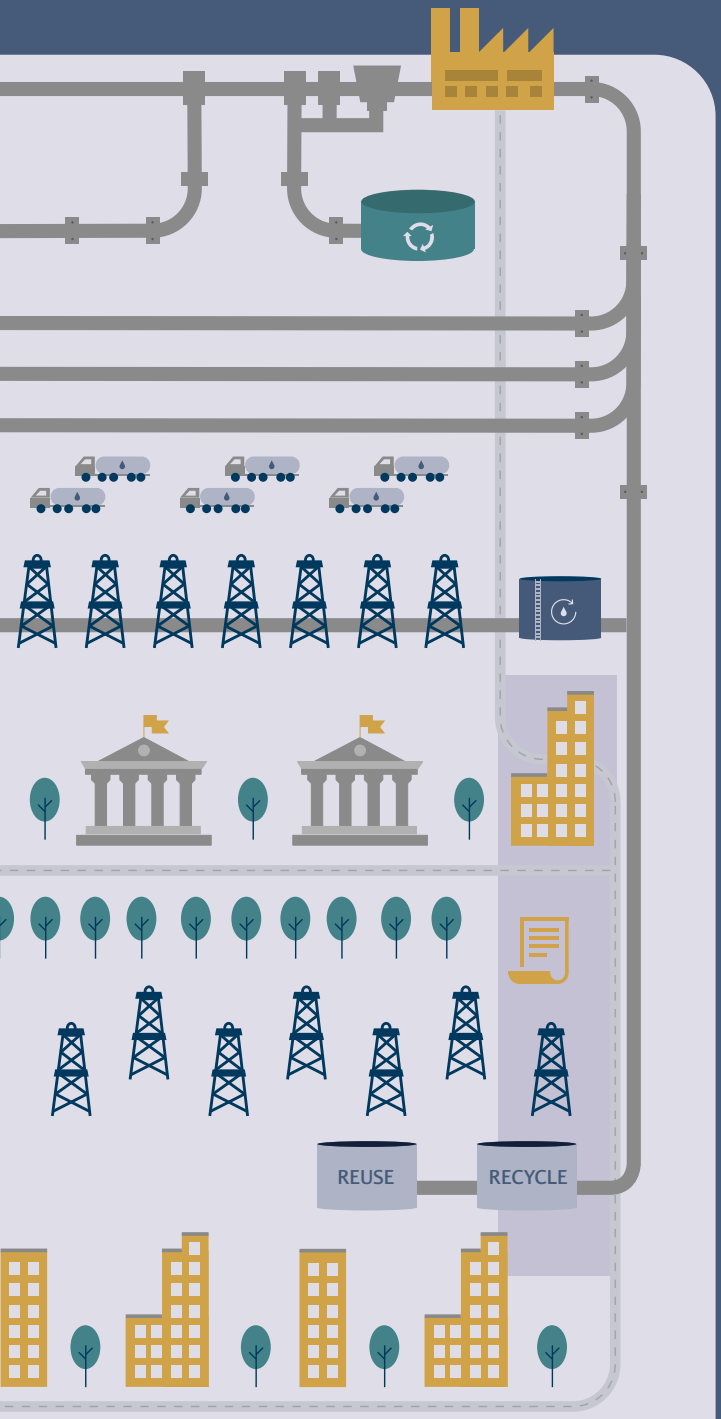


New thinking about water for oil and gas

Given the central role of water in oil and gas production, the industry needs to rethink conventional water acquisition and disposal methods, and invest in more efficient and sustainable technologies and practices. The companies that will succeed will be those that eliminate freshwater usage, and treat wastewater as a resource.

Water solutions that work for oil and gas

While the move to reused water is possible today, we think more technology and investment, and the introduction of clear state regulations, is needed for water reuse or recycled water to scale.



Water recycling

Recycling is treating wastewater to acceptable standards (tailored to the intended final use) through robust treatment technologies. The industry can help alleviate water shortages and create a new resource through the development of recycled water, which could be used for other industries.

Pipelines vs. trucking

Reducing transportation costs will inevitably drive investment in pipeline infrastructure for both produced water and freshwater. Although building pipeline infrastructure carries a high upfront capital expenditure, it reduces operating expenses down the line.

Wastewater reuse

We define reuse as wastewater reused within a well, which requires very little additional treatment. Reuse alone could lower water-related costs by about 45% and save 250,000 to 500,000 barrels of fresh water per well.

Public/private partnership

New opportunities for collaboration have created sustainable solutions for water management. For example, farmers in Texas and California are using recycled water from oil and gas for irrigation on non-food crops.

Industry guidelines/regulations

Clear and standardized regulations on water management and reporting for the oil and gas industry is crucial. The government should enable shared learning, encourage cross-industry collaboration, and carve out funding of new technologies for smaller players.

Alternative types of water

Enabling regulations and better data and management will encourage the sector to invest in infrastructure, and engage in public/private partnerships to source alternative water and collaborate with other industries.

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