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Technical Brief

Recent Trends in Water Use and Production for California Conventional and Unconventional Oil Production

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Issue

In 2012, California was the third largest oil producing state in the U.S. (ranked after Texas and North Dakota and before Alaska), producing 197 million barrels (MMbbls), or 1200 Petajoules (PJ), of oil from 52,190 wells. Although production has been declining, the Energy Information Administration (EIA) estimates that 3,000 MMbbls of proven reserves still remain in the state as of 2011. Water is a critical input to the petroleum production process, particularly in the extraction and refining stages. Water resources are severely constrained in California, and competition for water has become intense. While water use for oil production is not an overwhelming portion of state water use, these oil fields are located in areas projected to experience moderate to severe groundwater stress by 2025.

Research Findings

Conventional Oil (and Gas) Production. Total water use for oil production increased by 30% between 1999 and 2012 (Figure 1). Freshwater use increased over this time by 46% (from 9.8 to 14.3 billion liters). Overall, California used more freshwater for oil production due to increased use of tertiary recovery methods. The median value of total water use intensity of oil production of all types has increased 20% from 4.1 gal water/gal oil produced to 5.0 gal/gal during this period (1999-2012), while the 95th percentile has doubled from 21 gal/gal to 38 gal/gal. The water use intensity of freshwater doubled, from 0.2 gal fresh water/gal oil to 0.5 gal/gal, largely due to increased freshwater use by tertiary fields, and growing proportion of total oil produced using tertiary recovery.

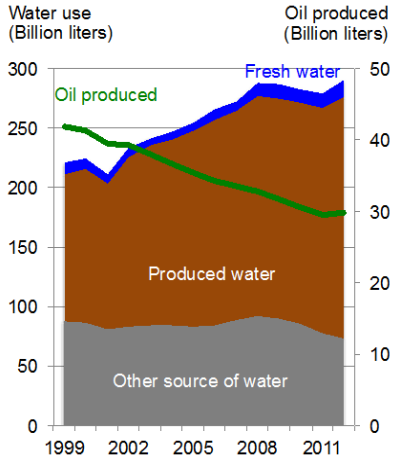

Figure 1. Water injected by type of water (left axis) and oil or condensate produced in California (right axis).

Produced Water Intensity. In petroleum production, water is produced along with oil and gas. The produced water is then re-injected into the oil/gas wells for additional recovery, discharged in evaporation ponds, or returned to the watershed for use by other sectors. As California oil fields age, produced water has increased from 1999 to 2012, with the majority disposed in injection wells mostly for reuse for enhanced oil recovery as well as for wastewater storage. Ninety-seven billion liters were sent to unlined percolation ponds in 2012, up from 62.5 billion liters in 1999, a 55% increase. Water disposal to surface water has increased as well, from 4.6 billion liters in 1999 to 8.9 billion liters in 2012. More of this water may soon be sold to agriculture, with additional pipelines being constructed from the Kern River oil field (which lies over part of the Monterey Shale deposit). As of 2014, California's record drought has pushed water prices to $2,200 per acre-foot, up from $300 in 2013. In comparison, produced water from Kern River is sold to farmers at $30 to $60 per acre-foot, making produced water an attractive alternative water source. There are concerns for health and ecological impacts of surface water disposal and "beneficial uses" of produced water, or recycling of produced water for crop irrigation, livestock watering, stream flow augmentation, and municipal and industrial uses.

Net Water Use Intensity. Net water use is the total water use for oil production subtracts produced water injected. Overall, California used more freshwater for oil production due to increased use of tertiary recovery

methods. There is also increased "other" water use for tertiary and mixed recovery, resulting in an overall increase in net water use. Increased produced water intensity and increased recycling rate for California oil fields result in moderately increased net water use intensity (30% increase from 1999 to 2012) and near doubling of net produced water intensity (from 4.6 gal/gal in 1999 to 8.8 gal/gal in 2012), with the highest increase in the mixed recovery category.

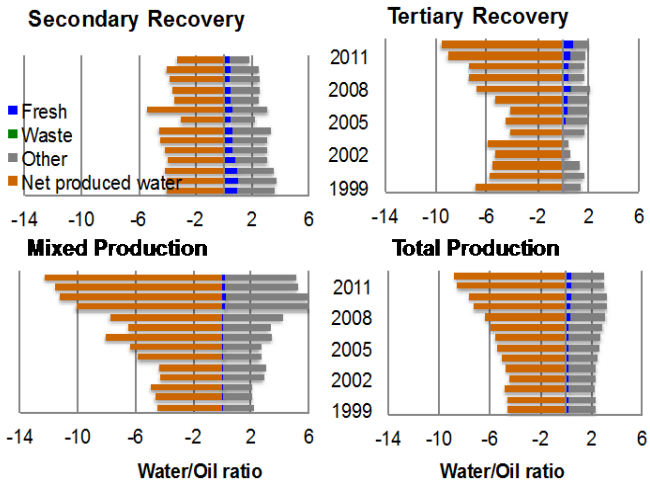

Figure 2. Net water use intensity (gal water / gal oil produced) of California oil fields (1999-2012)

Hydraulic Fracturing. Unconventional oil production from hydraulic fracturing represented a small portion of oil and gas production in 2012 and 2013. However, this could drastically change with technological advances necessary to exploit the Monterey Shale.

Hydraulic fracturing in California used 232 million liters in 2012 for 302 wells and 179 million liters in 2013 for 344 wells. This estimate is based on voluntary disclosures, and may not include wells that did not disclose or failed to produce oil or gas. There are several differences between the typical use of hydraulic fracturing in California and other states. In California, hydraulic fracturing is principally used to ensure that previously conventional wells attain maximum production. These are generally vertical wells, fracturing only tens to hundreds of feet from the well rather than horizontally. Other states, such as Texas and North Dakota, use horizontally drilled production wells and lengthy fracturing periods to access shale.

The mean reported water use per well are 0.18 million gallons per well (0.67 million liters per well) in 2012 and 0.13 million gallons per well (0.5 million liters per well) in 2013. This translates to an average of 3.5 gal water/ gal oil produced in 2012 and 2.4 gal/gal in 2013. The median values are 1.0 gal water/ gal oil produced in 2012 and 0.5 gal/gal in 2013.

Hydraulic Fracturing Flowback Water. Fracturing fluid that returns to the surface with extracted oil and gas resources is commonly referred to as flowback water or wastewater during the first 10 days to several months. The rate at which flowback water returns to the surface is highly dependent on the geology of the formation. In California, the total amount of flowback water was 1,465 million liters in 2012, averaging 4.5 million liters per well, translating to average flowback water ratios of 10.8 gal flow back water / gal oil) in 2012 and 16 gal/gal in 2013.

Policy Implications

Increasing volumes of produced water represent a growing concern and an opportunity; as freshwater becomes scarce, treated produced water can become an important additional water source. Water produced from oil wells can be directly reused in secondary recovery, whereas produced water has to be treated for tertiary recovery, which requires higher quality water/steam. Water use intensity estimates for hydraulic fracturing wells are much lower than their conventional counterparts in California, however, there are significant water quality concerns associated with chemicals used for hydraulic fracturing. While water use for oil production is not an overwhelming portion of state water use, many oil fields are located in counties with high agricultural freshwater use, creating possible conflicts in the future.

Further Reading

This policy brief is drawn from the forthcoming manuscript, *Tiedeman, K., Yeh, S., Scanlon, B., Teter, J., Mishra, G.S. Recent Trends in Water Use and Production for California Conventional and Unconventional Oil Production.*

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