

PETROLEUM WATCH

CALIFORNIA ENERGY COMMISSION

INSIDE

- Gasoline Retail Prices by Brand
- Diesel Retail Prices by Region
- 2020 California Well Counts
- 2020 California Oil vs. EOR Wells by Field
- Crude Oil Production in United States
- Enhanced Oil Recovery Survey
- California Crude Supply
- Carbon Intensity
- Featured Topic: California Crude Oil Extraction

REFINERY NEWS

• No Refinery News to report.

CALIFORNIA GASOLINE RETAIL PRICES BY BRAND

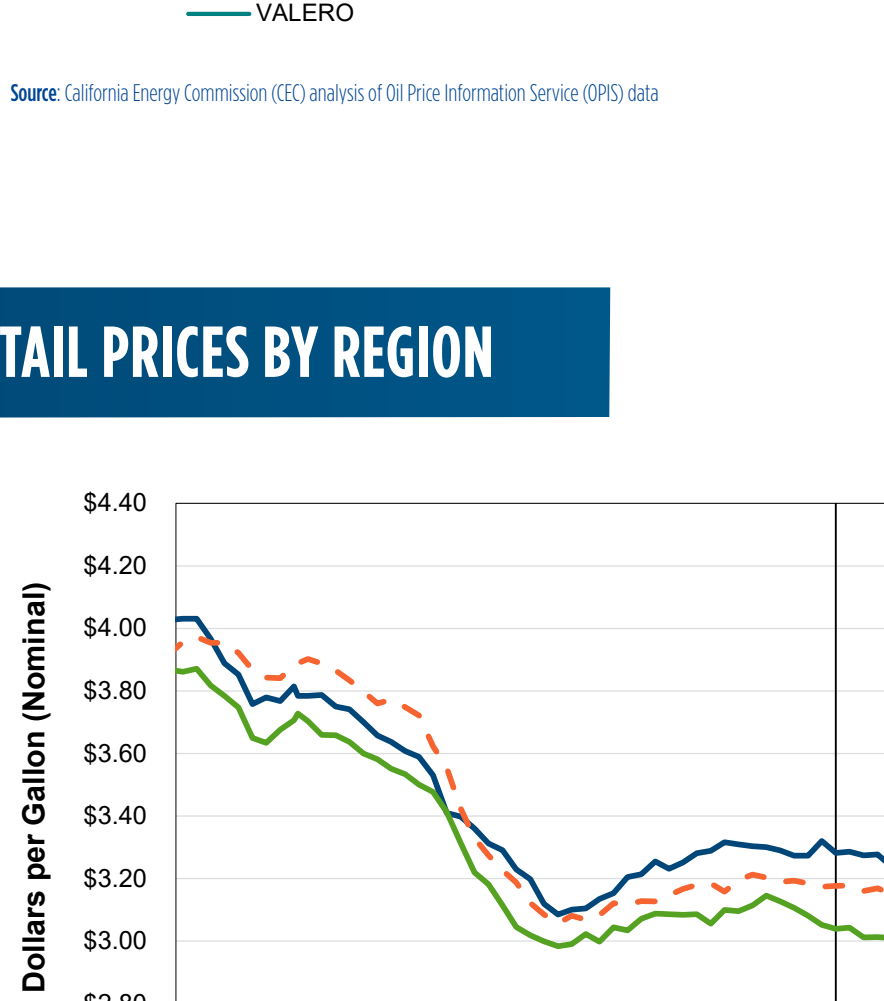
October 2020 vs. 2019

(Percentage Change)

76	23% lower
ARCO	25% lower
Chevron	21% lower
Hypermart	26% lower
Shell	22% lower
Unbranded	24% lower
Valero	22% lower

October 2020 Averages

76	\$3.26
ARCO	\$2.98
Chevron	\$3.38
Hypermart	\$2.87
Shell	\$3.33
Unbranded	\$3.06
Valero	\$3.19



Source: California Energy Commission (CEC) analysis of Oil Price Information Service (OPIS) data

CALIFORNIA DIESEL RETAIL PRICES BY REGION

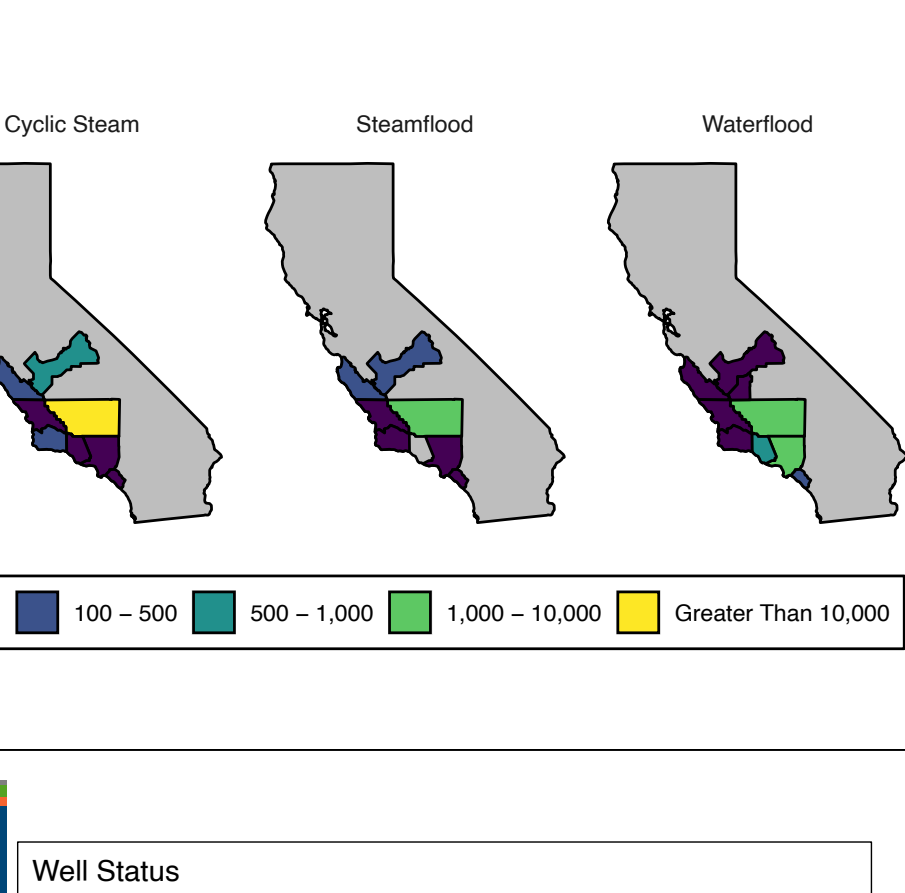
October 2020 vs. 2019

(Percentage Change)

Northern CA	18% lower
Central CA	21% lower
Southern CA	19% lower

October 2020 Averages

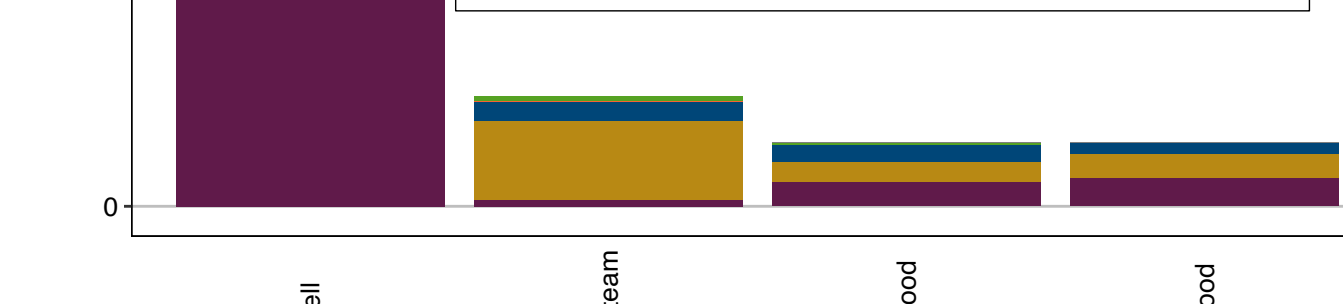
Northern CA	\$3.27
Central CA	\$3.02
Southern CA	\$3.17



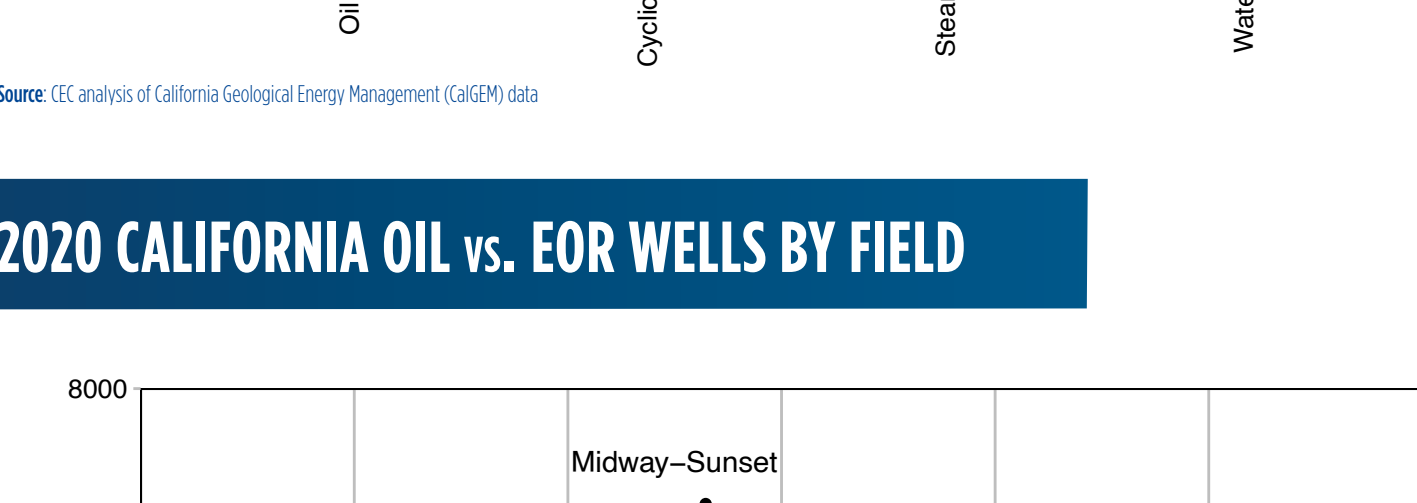
Source: CEC analysis of OPIS data

2020 CALIFORNIA WELL COUNTS

ACTIVE WELLS BY COUNTY

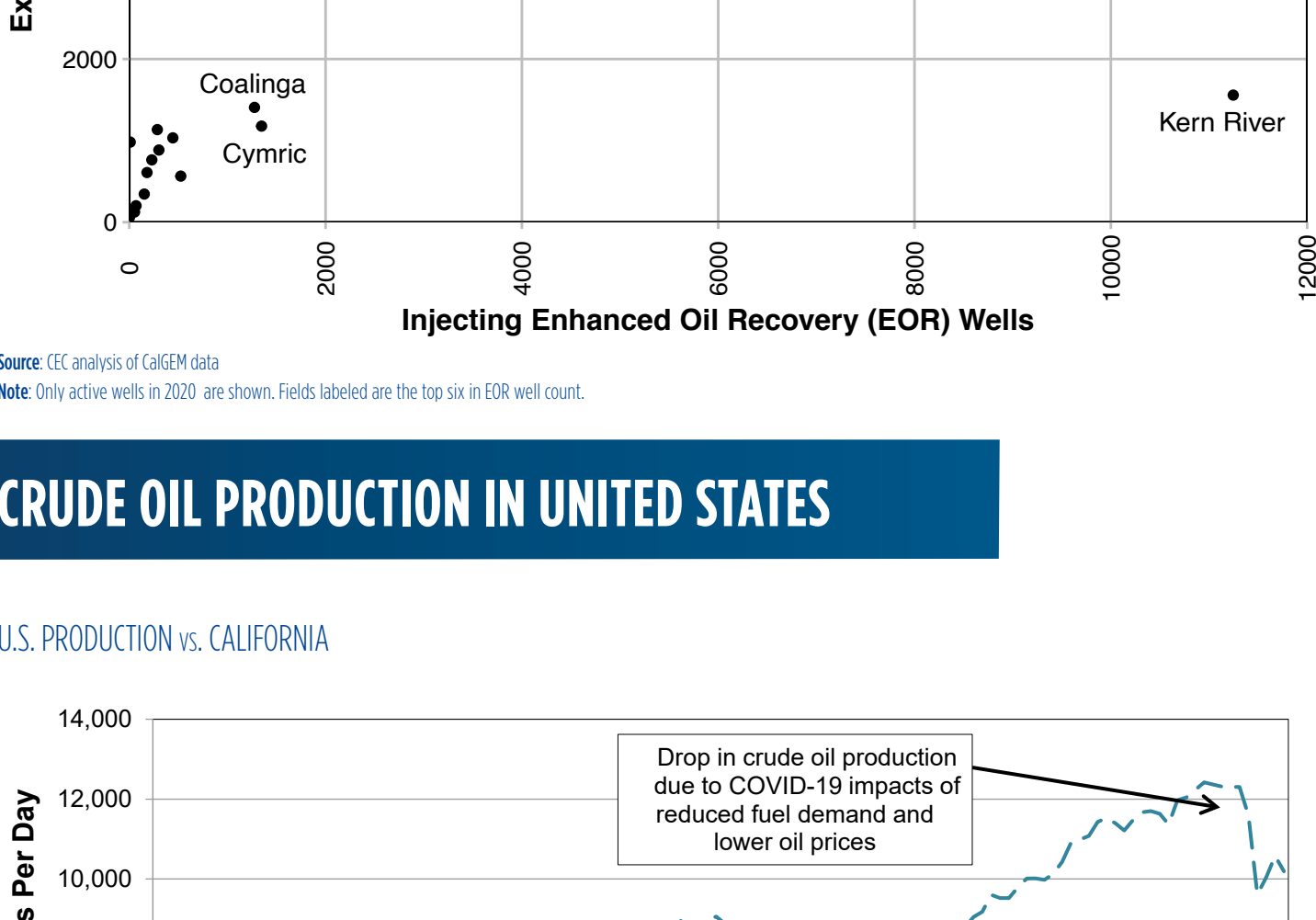


WELLS BY TYPE AND STATUS



Source: CEC analysis of California Geological Energy Management (CalGEM) data

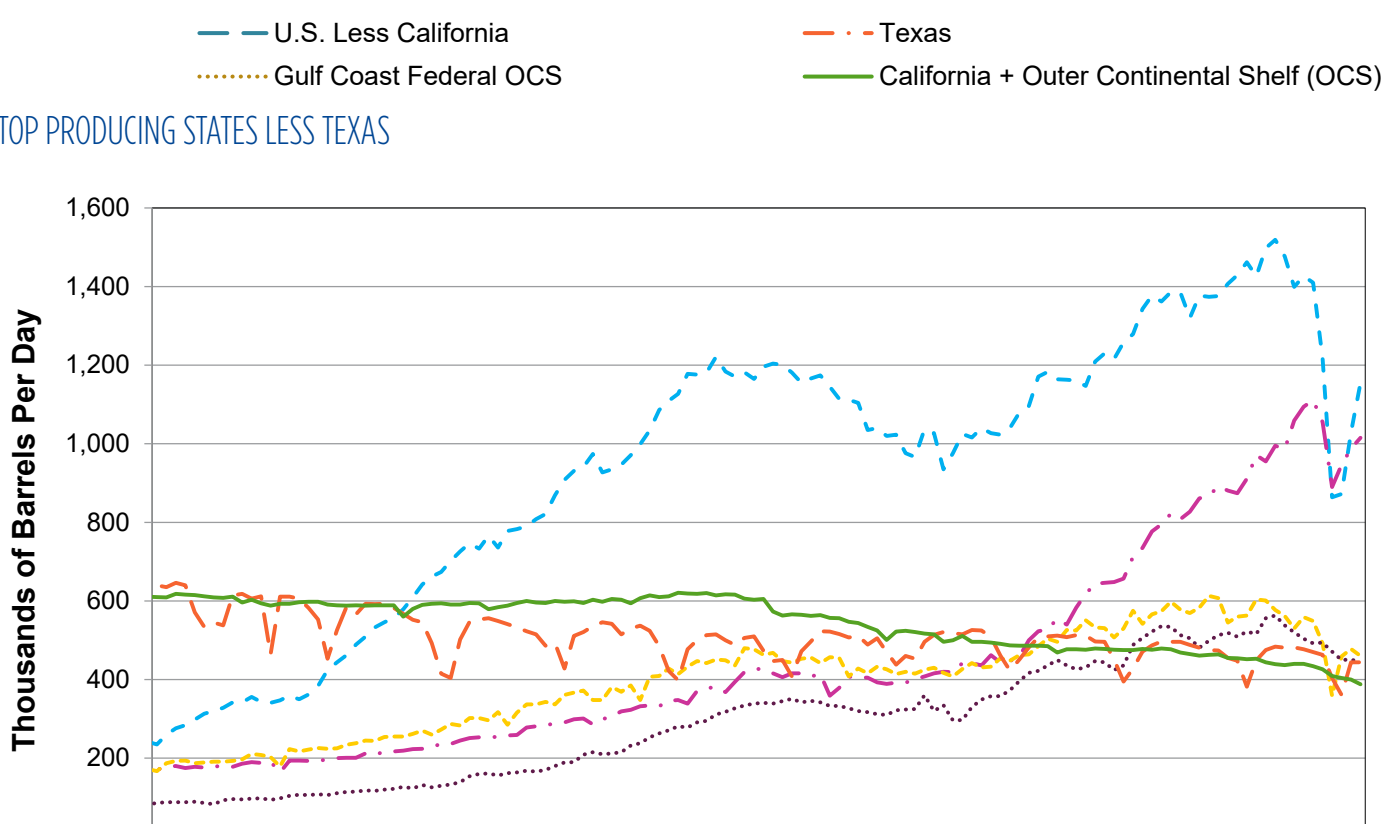
2020 CALIFORNIA OIL vs. EOR WELLS BY FIELD



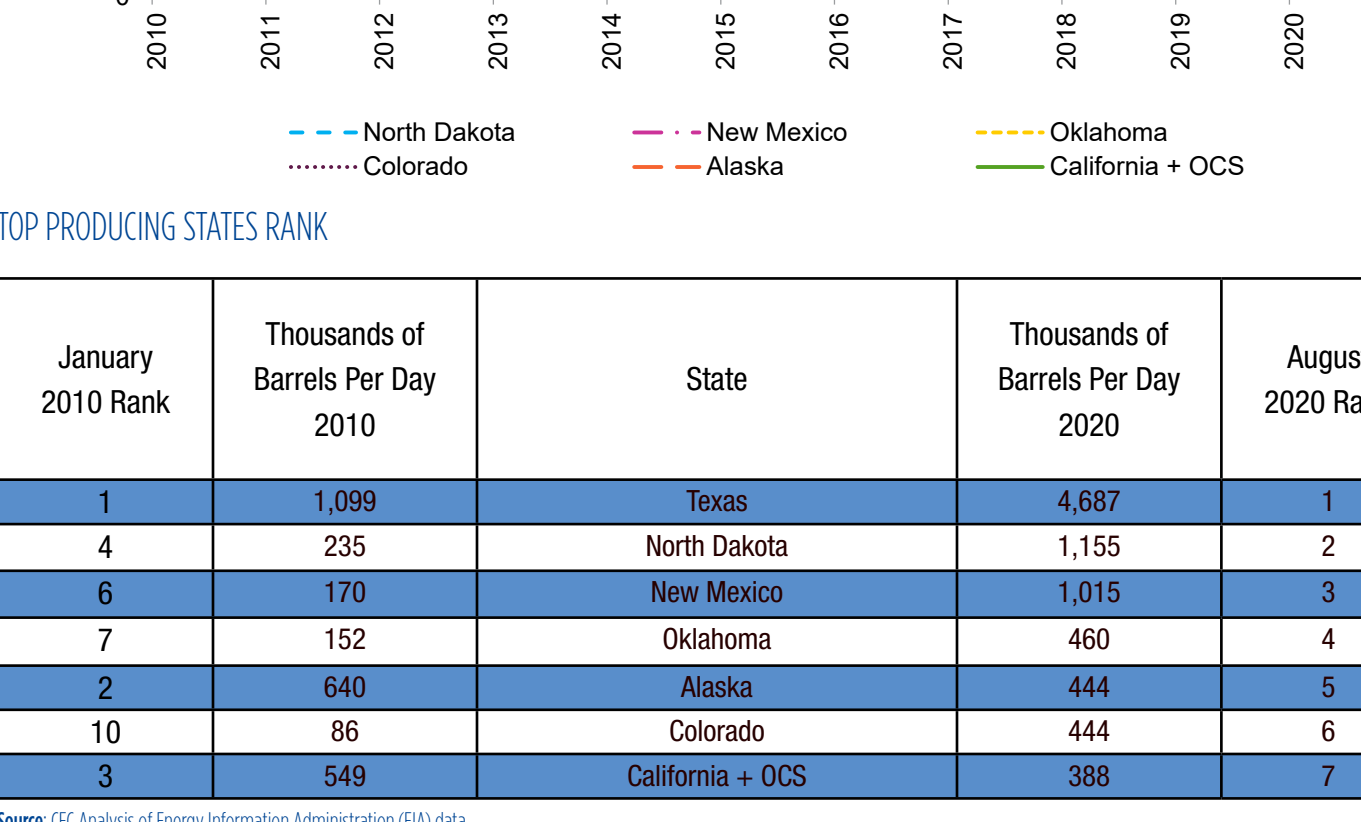
Source: CEC analysis of CalGEM data. Note: Only active wells in 2020 are shown. Fields labeled are the top six in EOR well count.

CRUDE OIL PRODUCTION IN UNITED STATES

U.S. PRODUCTION vs. CALIFORNIA



TOP PRODUCING STATES LESS TEXAS

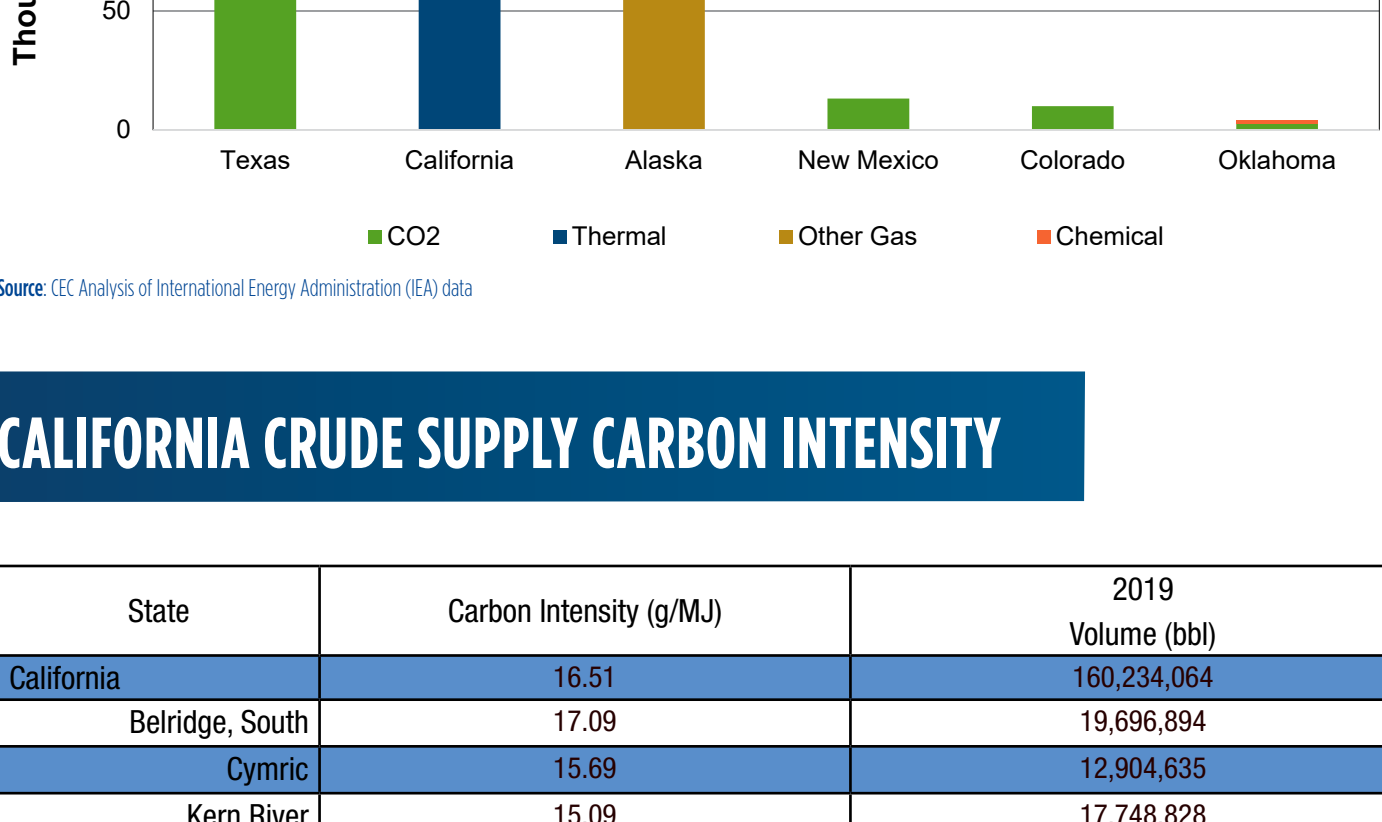


TOP PRODUCING STATES RANK

January 2010 Rank	Thousands of Barrels Per Day 2010	State	Thousands of Barrels Per Day 2020	August 2020 Rank
1	1,099	Texas	4,687	1
4	235	North Dakota	1,155	2
6	170	New Mexico	1,015	3
7	152	Oklahoma	460	4
2	640	Alaska	444	5
10	86	Colorado	444	6
3	549	California + OCS	388	7

Source: CEC analysis of Energy Information Administration (EIA) data

ENHANCED OIL RECOVERY SURVEY



Source: CEC Analysis of International Energy Administration (IEA) data

CALIFORNIA CRUDE SUPPLY CARBON INTENSITY

State	Carbon Intensity (g/MJ)	2019 Volume (bbl)
California	16.51	160,234,064
Belridge, South	17.09	19,696,894
Cymric	15.69	12,904,635
Kern River	15.09	17,748,828
Lost Hills	29.93	9,057,838
Midway Sunset	22.33	19,644,832
Wilmington	8.31	10,326,945
Alaska	15.91	75,345,560
New Mexico	11.11	1,146,069
North Dakota	9.73	328,964
Texas	11.93	1,420,258

Source: CEC analysis of California Air Resources Board (CARB) data

FEATURED TOPIC

CALIFORNIA CRUDE OIL EXTRACTION

Crude oil is a mixture of liquid hydrocarbons in underground geologic formations. The decision to drill for oil depends on how costly the oil is to extract. Well sites are selected after careful study of factors such as location, geology, and reservoir size. After a well site is chosen, an exploratory well is drilled and tested. If the site looks profitable, development wells are drilled followed by injection wells and production wells. Injection wells pump fluid or gas into the rock to allow the oil to flow easier for extraction. Production wells are used to pump the oil out from the reservoir. Final crude oil production enters three distinct phases: primary, secondary, and tertiary recovery.

CRUDE OIL PRODUCTION

Primary Recovery

Primary recovery, the first stage in oil recovery, yields about 10 percent of the reservoir's original oil in place according to the U.S. Department of Energy. Original oil in place is the total amount of oil located in an underground reservoir before the production. Primary recovery uses the natural pressure of the reservoir pushing crude oil to the surface. Millions of years of compression under thousands of feet of rock and high temperatures builds extreme pressure within the reservoir. When the well hits the reservoir, this pressure forces the oil through the rock and up to the surface. Natural pressure drops over time, prompting further recovery techniques.

Secondary Recovery

Secondary recovery uses an external force to move the oil to the surface. The most common technique is waterflooding. Wells are drilled to inject water, acting like giant hoses washing the oil from the porous rock through the reservoir into the production well. These techniques can extract about 20 to 40 percent of the reservoir's original oil in place.

Tertiary (Enhanced) Recovery

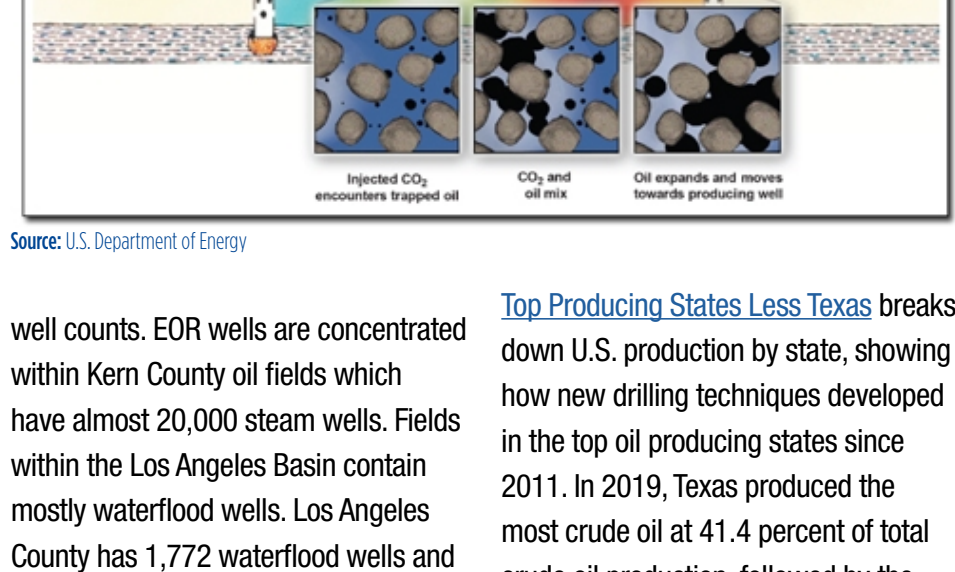
Tertiary recovery, also known as enhanced oil recovery (EOR), is a process used after primary and secondary recovery stages are complete. EOR can extract about 30 to 60 percent of the reservoir's original oil in place. There are three techniques of EOR: thermal recovery, gas injection, and chemical injection. Thermal recovery injects pressurized steam lowering the viscosity, or thinning, of heavy oil and increasing the flow through the reservoir to the well. There are two types of steam injecting: steamflood and cyclic. Steamflood is similar to waterflooding except with steam. Cyclic steam is a more involved process with three stages: injection, soak, and production. Gas injection pushes additional oil to production wells using gases such as natural gas, nitrogen, or carbon dioxide. Chemical injection uses long-chained molecules (polymers) to increase the effectiveness of waterflooding.

CALIFORNIA EXTRACTION

In California, the main techniques for oil extraction are waterflooding, thermal recovery, and gas injection. California is the largest user of thermal recovery in the United States because of California's viscous and heavy crude oil. Like heating up molasses to pour, thermal recovery uses steam to heat up the oil allowing it to easily flow through rock. [February Petroleum Watch](#) discussed the types of crude that California refineries source are heavier types with a higher sulfur content. California's refineries are especially suited to process the remaining heavy crude oil found in California's rock formations. In-state oil production has declined over the past 30 years due to economic and environmental reasons. As of 2019, California refineries import about 70 percent of their crude oil from Alaska and foreign sources.

Most of California's oil production occurs within the San Joaquin Valley and Los Angeles Basin as shown in [Active Wells by County](#). Kern County has the largest quantity of active oil wells at 30,814 wells. Los Angeles County is second at 4,445 active wells, followed by 1,871 active wells in Ventura County. There are additional offshore oil extraction operations in the California (federal waters being further out) within Los Angeles, Santa Barbara, and Orange counties, these are included in each county's respective

EXAMPLE OF INJECTION WELL AND PRODUCTION WELL



Source: U.S. Department of Energy

well counts. EOR wells are concentrated within Kern County oil fields which have almost 20,000 steam wells. Fields within the Los Angeles Basin contain mostly waterflood wells. Los Angeles County has 1,772 waterflood wells and 58 EOR wells. Ventura County has 541 waterflood wells and 11 steam wells.

WELLS BY TYPE AND STATUS

[Wells by Type and Status](#) breaks down the producing and injecting wells reported to the California Geologic Energy Management Division (CalGEM). According to the [2020 Production and Injection Reports](#), there are 39,573 active producing oil wells. The total number of steam injecting wells is 22,307, with 5,419 waterflood wells. Newly permitted production and injecting wells in 2020 include 2,639 oil, 1,504 steam, and 124 waterflood wells. Since California oil reservoirs are aged and contain heavier, thicker crude, there is a large number of wells using thermal recovery techniques. Some fields use waterflood wells in addition to thermal, such as South Belridge which holds 1,317 active waterflood wells and 1,703 steam wells.

Idle oil wells are wells that have become too costly to operate. Like the amount or quality of the crude oil decreases below the cost to keep pumping, the well must be plugged to prevent any leaks over time that could contaminate the surface or groundwater above the oil reservoir. There are currently 63,734 plugged oil wells and 26,965 idle oil wells reported in California. This includes wells that are used for production and injection. CalGEM has an [Idle Well Program](#) that assists owners to properly plug and abandon inactive wells.

2020 Extracting Oil Wells vs Injecting Enhanced Oil Recovery (EOR) Wells

[by Field](#) shows the relation between number of oil wells (extracting) and the number of EOR wells (steam injecting) at each California oil field. The Coalinga field is home to all 1,276 steam injecting wells within Fresno County. Kern River has the most EOR wells, with 11,247 steam wells and 1,558 extracting oil wells. Each field has different geological properties from the other and some fields need more EOR wells than others.

CALIFORNIA PRODUCTION COMPARED TO OTHER STATES

[U.S. Production vs. California](#) shows national crude oil production, Texas crude oil production, Gulf of Mexico crude oil production, and California and the Outer Continental Shelf (OCS) crude oil production. The OCS represents the oil production in federal waters off the coast of California. Texas drove U.S. crude oil production growth over the past 10 years. While U.S. oil production has increased since 2011, California has steadily declined. California oil production declined 34 percent from January 2011 to August 2020, an ongoing trend since production in the state peaked in 1985. Outside of California, U.S. oil production increased 92.5 percent from January 2011 to August 2020. The rise came through the development of new shale oil deposits, improved drilling efficiency, and increased use of hydraulic fracturing. Hydraulic fracturing, or fracking, works by injecting pressurized water, sand, and chemicals to break up rock formations in an effort to increase the flow of oil. The large shale oil formations in Texas are ideal for fracking because they consist of brittle rock formations that contain crude oil and natural gas. Although California contains some shale deposits, a similar surge of oil production has not yet happened. California's geology is different from Texas and makes the drilling too difficult for oil producers to use the same techniques.

Top Producing States Less Texas

[breaks down](#) U.S. production by state, showing how new drilling techniques developed in the top oil producing states since 2011. In 2019, Texas produced the most crude oil at 41.4 percent of total crude oil production, followed by the Gulf of Mexico at 15.5 percent, North Dakota at 11.6 percent, New Mexico at 7.4 percent, Oklahoma at 4.7 percent, Colorado at 4.2 percent, and Alaska at 3.8 percent. While California's crude oil production has declined, the state accounts for 3.6 percent of total U.S. production in 2019, and is still a top 10 producer of crude oil in the nation. [Top Producing States Rank](#) shows state ranks in January 2010 compared to August 2020. Texas, a consistent top producer, doubled previous production with hydraulic fracturing. North Dakota rose in rank to second largest producing state using large hydraulic fracturing techniques. Decreased production caused the ranking of Alaska and California to drop.

Extraction techniques vary depending on the geology of an oil reservoir.

Techniques using thermal extraction work well for California's viscous oil, but others like gas injection do not. In gas injection, carbon dioxide (CO2) gas is injected, increasing pressure to extract oil, but this only works with less viscous, lighter, crude oil. The light crude oils in the large brittle rock shale formations in Texas and North Dakota are ideal for gas injection.

The International Energy Agency (IEA) published 2017 data on production oil fields and EOR usage. [Enhanced Oil Recovery Survey](#) shows the survey results from this partial list of oil fields in the United States is gathered from the public domain and by input from industry and government sources. California primarily uses thermal recovery through injection of steam. Texas, New Mexico, and Colorado primarily use gas injection recovery using CO2. Alaska and small portions of Texas and California use gas injection of other gases, likely natural gas or nitrogen. Oklahoma uses a combination of CO2 injection and chemical injection. The least common extraction method is the least common extraction method, comprising an estimated one percent of EOR methods in the United States.

California extraction techniques are the most energy intensive compared to other states that supply crude oil to California. Carbon intensity (CI) scores of crude oil supplied to California refineries, published by the California Air Resources Board (CARB), adds insight on extraction methods in the United States. [California Crude Supply Carbon Intensity](#) lists California and OCS regions as a whole, California's top six EOR fields and other states' crude oil CI scores, and volume of crude oil supplied to California refineries in 2019. This analysis is based on a direct relation between carbon intensity and energy intensity.

California's carbon intensity score of 16.51 grams of carbon dioxide equivalent per megajoule (MJ) of oil extracted (gCO2e/MJ) is the weighted average of all California's producing oil fields and OCS regions. Of the top six EOR fields in California, Midway Sunset has the highest CI score of 29.33 g/MJ, followed by South Belridge at 17.09 g/MJ. These high scores are attributed to the high energy usage of thermal recovery. Heating up water to create steam is an energy intensive process. It must be sustained for long periods of time while the steam is continually injected into the rock formation.

Conversely, the lower CI scores of crude oil from hydraulically fractured wells in Texas (11.93 g/MJ) and North Dakota (9.73 g/MJ) is lighter and flows with either natural pressure or gas injection with no additional heat needed.

FOR MORE INFORMATION
California's Petroleum Market
Weekly Fuels Watch
Subscribe

SPECIAL THANKS
Transportation Fuels Data Analysis Unit

Gavin Newsom
Governor

Karen Douglas, J.D.
J. Andrew McAllister, Ph.D.
Patty Monahan
Commissioners

David Hochschild
Chair

Drew Bohan
Executive Director

Jane A. Scott, J.D.
Vice Chair



CALIFORNIA ENERGY COMMISSION

