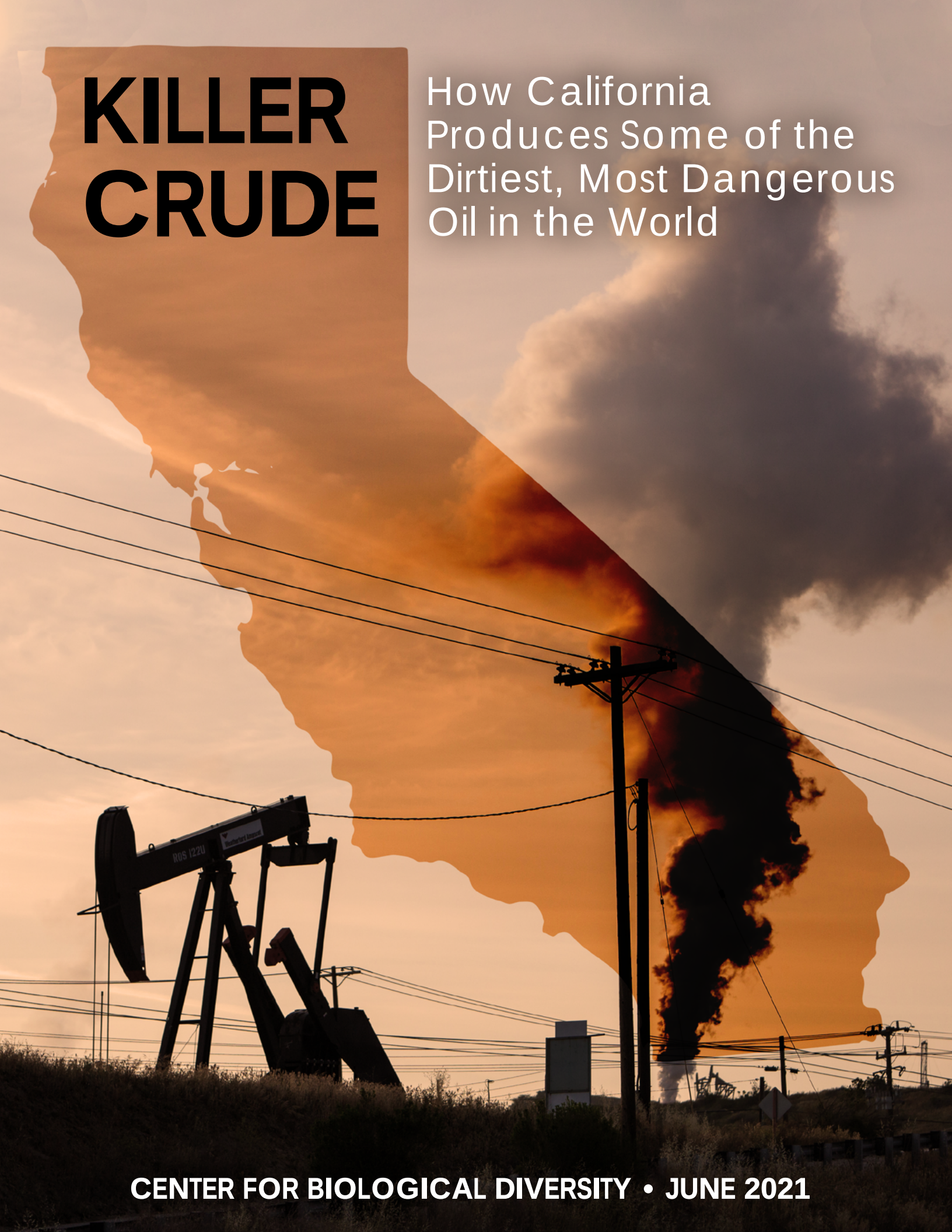
KILLER CRUDE

How California Produces Some of the Dirtiest, Most Dangerous Oil in the World



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KILLER CRUDE: HOW CALIFORNIA PRODUCES SOME OF THE DIRTIEST, MOST DANGEROUS OIL IN THE WORLD

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Executive Summary

Despite California's reputation as a global climate leader, California-sourced oils are now among the most climate-damaging in the world and are rapidly becoming even more so. This report analyzes the state's oil production and refining to show the dramatic increase in California oil's carbon intensity over roughly the past decade. It finds that California-sourced oils have gone from bad to worse and are now dirtier than oils refined here from other states and global regions including the Middle East, South America, Africa, Canada and Mexico.

California has a huge impact as the nation's seventh-largest producer of crude oil and the third-largest oil refiner. In 2020 California oil companies produced more than 144 million barrels of crude oil, and state regulators issued more than 1,900 permits for new oil wells. This takes our state in the wrong direction at a critical juncture, as the scientific consensus tells us that we must phase out fossil fuel extraction to keep global heating below 1.5 degrees Celsius and prevent climate catastrophe.

Our findings on the worsening carbon intensity of California oil give state leaders an even greater opportunity — and responsibility — to confront ongoing health harms, climate damage and environmental racism by ending new oil and gas approvals and immediately banning fracking in the state. In April 2021 Gov. Gavin Newsom ordered state regulators to ban fracking by 2024 and study the phaseout of California oil production by 2045, but the climate and health crises demand action now, not decades in the future.

We studied upstream carbon intensity values (from exploration to refinery gate) provided by the California Air Resources Board for all oils refined in California. We found that the average carbon intensity of all oil refined in California is increasing, but the average carbon intensity of just the oil produced in California is increasing far faster. The carbon intensity of California-sourced oil is growing at twice the rate of all oils refined in California, and nearly three times the rate of oils produced outside of California (Figure E1). By 2019 the average carbon intensity of California-sourced crudes was more than one-and-a-half times greater than that of crudes produced outside of California.

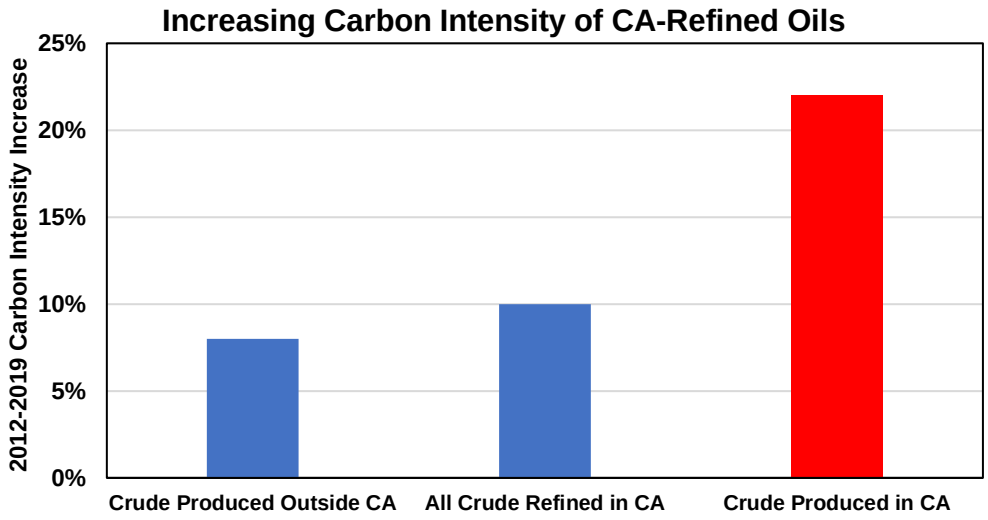


Figure E1: Increase in average carbon intensity between 2012 and 2019 for: (1) crude produced outside CA; (2) all crude refined in CA; (3) crude produced in CA.

Further evidence of California-sourced oil's outsized carbon footprint can be found in its contribution to the average carbon intensity of California-refined oil. California oil was 31% of all oil refined in California between 2012 and 2019 but was responsible for 39% of upstream carbon emissions.

Thus, on average, California oil emits more carbon dioxide per barrel than the rest of the global supply refined in California. So, although California oil production is declining, the increase in carbon intensity is helping to cancel out the climate benefits of declining production.

We also found that oil produced and refined in California is more climate-damaging than the notoriously dirty Canadian tar sands crude refined here. In 2019 the average upstream carbon intensity of California-sourced oil exceeded that of Canadian tar sands crude refined in California, with 98 kg CO_2eq/barrel for California oil and 90 kg CO_2eq/barrel for Canadian tar sands crude.

To avoid the worst dangers of climate change, the world must transition away from fossil fuels. No jurisdiction is better suited than California to lead the way in phasing out dirty oil and gas production. For California this means an end to approvals for new oil and gas wells and an immediate ban on fracking and related extreme techniques that only amplify the damage from extraction.

While a full phaseout of in-state production will take some time, it needs to be much faster than Gov. Newsom's 2045 target. A health-and-safety buffer should also be implemented immediately to prevent oil and gas drilling in communities and to protect public health and safety from air pollution and other harms of oil and gas extraction. Without taking these steps, California cannot protect the climate or the state's most vulnerable communities.

San Ardo Oil Field by Loco Steve/Flickr

Introduction: California's Oil Production Undermines Its Climate, Environmental Justice and Public Health Goals

Despite California's image as a leader on climate and the environment, the state's oil industry contributes heavily to dangerous climate-heating pollution. California is the nation's seventh-largest producer of crude oil and the third-largest oil refiner.[1] In 2020, California oil companies produced more than 144 million barrels of crude oil, while Gov. Newsom's state regulators issued more than 1,900 permits for new oil wells.[2] The flood of permits for new oil wells runs directly counter to the imperative to phase out fossil fuel extraction to prevent the worst climate damages. It also perpetuates the environmental justice and health crises caused by oil and gas extraction in California.

Overwhelming scientific consensus has shown that without deep and rapid emissions reductions, global warming will exceed 1.5 degrees Celsius compared to preindustrial levels, resulting in catastrophic damage around the world.[3] Every fraction of additional warming above 1.5 degrees will worsen these harms, threatening lives, livelihoods, the environment and global security for this and future generations. Because 75% of global greenhouse gas emissions and 85% of U.S. emissions come from fossil fuels,[4] phasing out fossil fuel extraction and combustion is of urgent necessity to avert climate catastrophe.

Unfortunately, today the world faces a fossil fuel "production gap" of tremendous proportions: Producers currently plan to extract far more fossil fuels than a livable planet will allow.[5] There is enough oil, gas and coal in already developed fields and mines globally — that is, places where the infrastructure is built and the capital is sunk — to far exceed the carbon budget for 1.5 degrees C if these reserves were all produced and burned.[6] This means that meeting global climate goals

requires an immediate halt to the approval of new fossil fuel projects and a phaseout of existing oil, gas and coal extraction *before* the reserves in existing fields and mines are fully depleted.[7]

Nowhere in the world is better suited than California, with its wealthy, diverse economy and vibrant clean energy sector, to lead the way in a rapid phaseout of oil and gas extraction. To date, however, progress has been slow and insufficient. Gov. Newsom's order for regulators to study how to phase out oil extraction by 2045 could allow another two and a half decades of toxic inaction.

To make matters worse, much of the remaining oil in California's largest oilfields is heavy and carbon intensive.[8] The "heaviness" of an oil is defined by its API gravity, which is a measure of the oil's density. A crude oil is "light" if it has an API gravity of more than 31.1 degrees, "medium" if it has an API gravity from 22.3 to 31.1 degrees, "heavy" if it has an API gravity from 10 to 22.3 degrees and "extra heavy" if under 10 degrees. In 2018, 68% of California's crude oil production was heavy.[9] Heavy oils are especially climate-damaging because they often require energy-intensive techniques such as hydraulic fracturing, waterflood, steamflood and cyclic steam to extract. This greater energy demand results in greater greenhouse gas emissions as well as greater health and safety risks.

The heaviness of oil contributes to its carbon intensity, with heavier oils tending to be more carbon intensive. Carbon intensity is a value that estimates the emissions from the production, processing and transport of crude oil. Our study of carbon intensity values for oil refined in California, provided by the California Air Resources Board, shows that California-sourced oils are especially dirty in a global context and that their carbon intensity is rapidly increasing.

Oil and gas production in California has also caused an environmental justice and public health crisis in California. Eighteen percent of the state's population lives within a mile of at least one oil or gas well.[10] The highest-density oil and gas extraction areas are predominantly located near low-income communities and communities of color.[11] These communities are disproportionately exposed to the health harms associated with oil and gas extraction such as cancer,[12] respiratory illnesses[13] and pregnancy complications. Two recent studies focused on California specifically found associations between proximity to oil and gas production and preterm birth and low birth weight.[14] A recent Harvard study found that an estimated 34,000 Californians died prematurely in one year because of fossil fuel pollution.[15]

California's failure to rein in the dirty oil extraction within its own borders, using increasingly energy-intensive and dangerous techniques, completely undermines its climate, health and justice goals.

Study Description

California refines crude oil from countries around the world, including (as of 2019) Angola, Argentina, Brazil, Canada, Colombia, Ecuador, Equatorial Guinea, Ghana, Iraq, Kuwait, Mexico, Nigeria, Oman, Peru, Russia, Saudi Arabia, Trinidad and United Arab Emirates. California also refines oil from other U.S. states including Alaska, New Mexico, North Dakota, Texas and Utah, along with oil from federal offshore sources. The remaining oil refined in California comes primarily from its own 158 major oilfields.

California's 2019 oil production was only 27% of the total 600 million barrels refined in California.[16] In 2019, 13% of the oil refined in California was from other U.S. states, predominantly Alaska, New Mexico, North Dakota, Utah and Wyoming. Notably, the oils refined from these states were all light based on API gravity.[17] Similarly, oil refined in California from the Middle East (mainly Saudi Arabia, Iraq and Kuwait), constituting 26% of oil refined in California in 2019 and the dominant foreign source, was light.[18]

The only significant foreign source of heavy oil refined in California is South America (mainly Ecuador, Colombia and Brazil), constituting 22% of oil refined in 2019.[19] Oils from Canada and Mexico, including the infamous Canadian tar sands oils, are comparable in heaviness to California oils, but as less than 5% of the total oil refined in California in 2019, they are a relatively small source.[20]

For oil refined in California, the Oil Production Greenhouse gas Emissions Estimator (OPGEE) is the model used to estimate the emissions from oil from different sources, or the carbon intensity, extending from initial oil exploration to the arrival of the oil at the refinery gate.[21]

Since 2012 the California Air Resources Board (CARB) has provided carbon intensity estimates for all oils refined in California, measured in grams CO_2 per megajoule (g/MJ — grams of CO_2 eq produced per MJ of energy derived from oil).[22] The carbon intensity values are attributed to the production and transport of the crude oil supplied as petroleum feedstock to California refineries, so emissions that occur during the refining process or thereafter are not considered. Carbon intensity (CI), as a measure of greenhouse gas emissions derived from a given crude, is one way to quantify the relative harms of different crudes to the climate.

Using the carbon intensity values of the various refined oils, CARB calculates an average carbon intensity for a given year by doing a weighted average based on the volume of oil from a given source:

$$Average\ carbon\ intensity = \frac{(Crude\ Vol.\#1 * CI\ \#1) + (Crude\ Vol.\#2 * CI\ \#2) + (Crude\ Vol.\#3 * CI\ \#3) + \cdots}{Total\ Volume\ of\ Oil\ Refined\ in\ CA}$$

where "crude vol." is the amount of oil from a given source and "CI" is the corresponding carbon intensity of that oil.

For our study, we used the same method and CARB's own average carbon intensity values of individual crudes to determine the average carbon intensity of different subsets of oil refined in California, including the average carbon intensity of only oils produced in California and only oils produced outside of California. The following is an example calculation of the average carbon intensity of oil from California oilfields:

$$Average\ carbon\ intensity\ of\ CA\ oil = \frac{(Crude\ Vol.\ CA\ \#1 * CI\ CA\ \#1) + (Crude\ Vol.CA\ \#2 * CI\ CA\ \#2) + (Crude\ Vol.CA\ \#3 * CI\ CA\ \#3) + \cdots}{Total\ Volume\ of\ Oil\ Produced\ and\ Refined\ in\ CA}$$

where "crude vol. CA" is the amount of oil from a given California oilfield and "CI CA" is the corresponding carbon intensity of that oil.

Using a conversion factor of 5,813.4 MJ per barrel as an approximation,[23] all carbon intensity values in the following analysis were converted from grams CO_2 per megajoule to kilograms CO_2eq per barrel (kg CO_2eq/bbl). With carbon intensity in terms of barrels and using values for barrels of oil production, upstream emissions from oil refined in California between 2012 and 2019 were also estimated.

Oil field in Bakersfield by Babette Plana/Flickr


San Ardo Oil Field by Drew Bird Photography

Results

The carbon intensity of oil produced in California has increased 22% since 2012, increasing the overall carbon intensity of all crude refined in the state.

The average carbon intensity of all crudes refined in California has gone up 10% between 2012 and 2019, increasing from an average of 66 kg CO_2eq/barrel in 2012 to 73 kg CO_2eq/barrel in 2019. This is an increase of about 1.5% per year. Meanwhile, for just the crudes extracted from California oilfields, the average carbon intensity has gone up 22% between 2012 and 2019, increasing from 81 kg CO_2eq/barrel in 2012 to 98 kg CO_2eq/barrel in 2019. This is an increase of about 3.1% per year or double the rate of increase for the carbon intensity of all oils refined in California. For all crudes not produced in California, the average carbon intensity has gone up 8% between 2012 and 2019, increasing from 59 kg CO_2eq/barrel in 2012 to 64 kg CO_2eq/barrel in 2019. This is an increase of about 1.2% per year, or about half the increase observed for crudes produced in California (Table 1, Figure 1).

So, although the average carbon intensity of all oil refined in California is increasing, the average carbon intensity of California-produced oil is increasing far faster: twice the rate of all oils refined in California, and nearly three times the rate of oils originating outside of California. This complements an earlier estimate that the carbon intensity of California crudes on a per barrel basis increased by 39% between 2000 and 2017.[24]

Year	All Crude Refined in CA	CA-Produced Crude	Crude Produced Outside CA
2012	66.04	80.57	58.89
2013	66.10	80.63	58.72
2014	65.05	82.26	56.45
2015	70.11	86.97	61.80
2016	70.57	87.55	62.67
2017	69.35	87.72	62.32
2018	71.80	97.20	62.96
2019	72.78	98.07	63.66

Table 1: Average carbon intensity (CI) of oil refined in California between 2012 and 2019 in units of kg CO_2eq/barrel: (1) all crude refined in CA; (2) CA-produced crude; (3) crude produced outside CA.

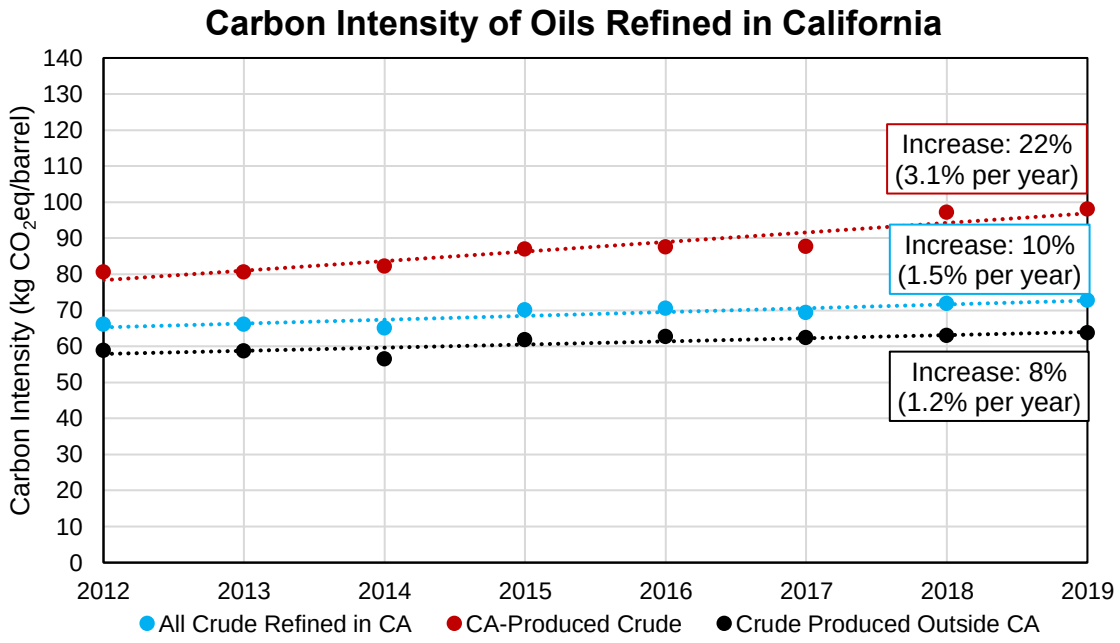


Figure 1: Increase in average carbon intensity over time for: (1) all crude refined in CA; (2) CA-produced crude; (3) crude produced outside CA.

<u>The high carbon intensity of California-sourced oils can be traced to just a few key California oilfields.</u>

As of 2019, California had 158 major oilfields, but five oilfields contributed more to California's average carbon intensity and upstream emissions than all others combined. These five fields in order of decreasing contribution are Midway-Sunset, South Belridge, Cymric, Kern River and San Ardo. Between 2012 and 2019, Midway-Sunset contributed 22% of the estimated upstream emissions from California-sourced oils; South Belridge contributed 12%; Cymric contributed 10%; Kern River contributed 9% and San Ardo contributed 8%. The remaining 39% was contributed by the other 153 major California oilfields (Figure 2):

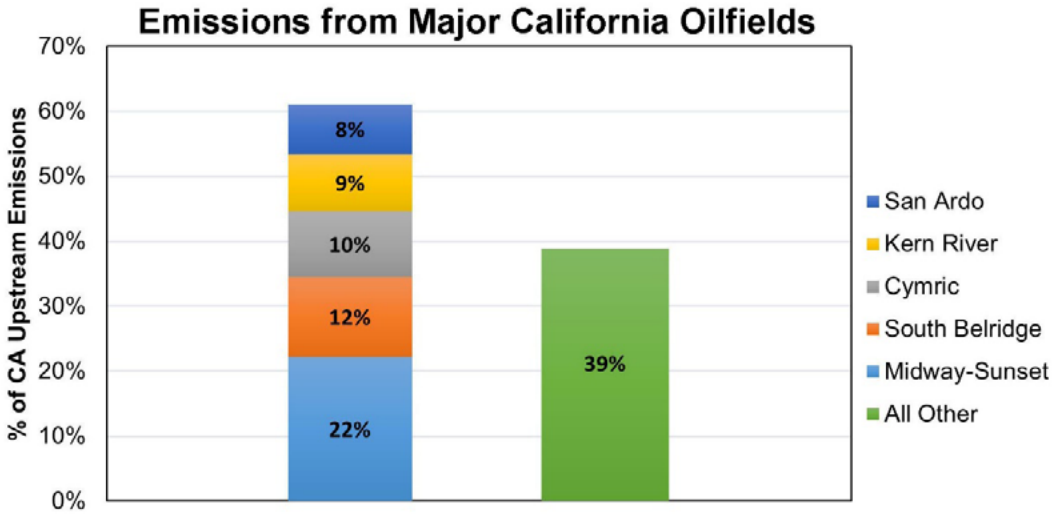


Figure 2: The top 5 California fields in terms of their contributions to the average carbon intensity and upstream emissions of California-sourced oils between 2012 and 2019. "All other" refers to all California oilfields outside of the top 5.

The contribution of specific oilfields to the average carbon intensity of California-sourced oils is strongly linked to total oil production (Figure 3), with Midway-Sunset, Kern River, South Belridge and Cymric being in the top five for contributing to California-sourced oils' average carbon intensity and the top five for California oil production. San Ardo, though in the top five for its contribution to California carbon intensity, ranks eighth in terms of oil production. The discrepancy is due to the relatively high carbon intensity of San Ardo oil.

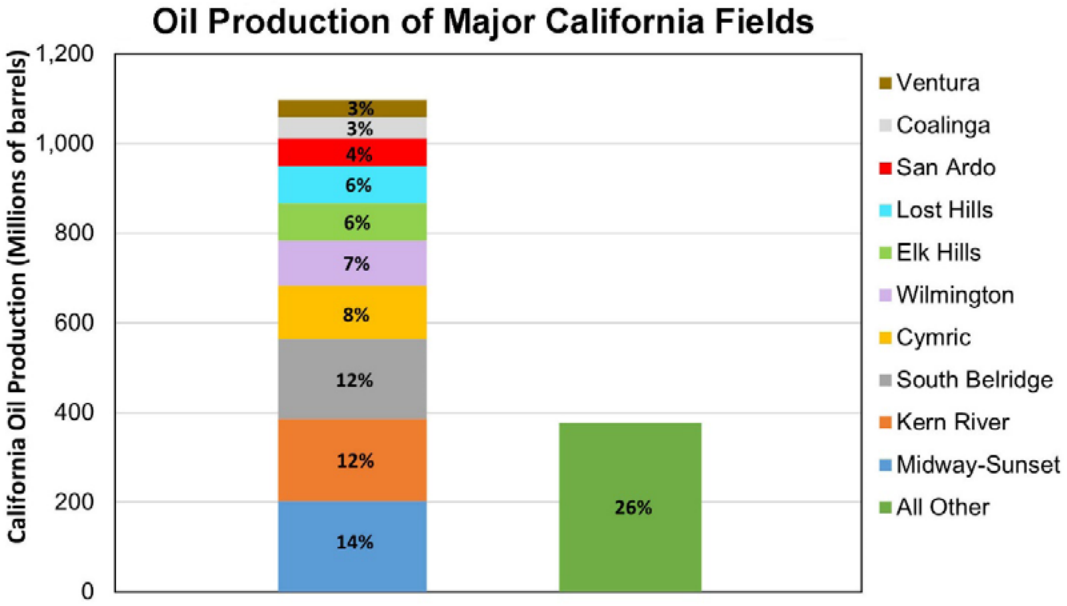


Figure 3: California's top 10 oilfields in terms of cumulative oil production between 2012 and 2019. Percent values displayed represent the percent of total California oil production. "All other" refers to all California oilfields outside of the top 10.

In terms of their contribution to the average carbon intensity of California-sourced oils, none of the top five California oilfields are in the top five for individual carbon intensity, although all are in the top 20 (Figure 4). This highlights the importance of both carbon intensity and production volume in determining the contribution of any given oilfield to the average carbon intensity and upstream emissions.

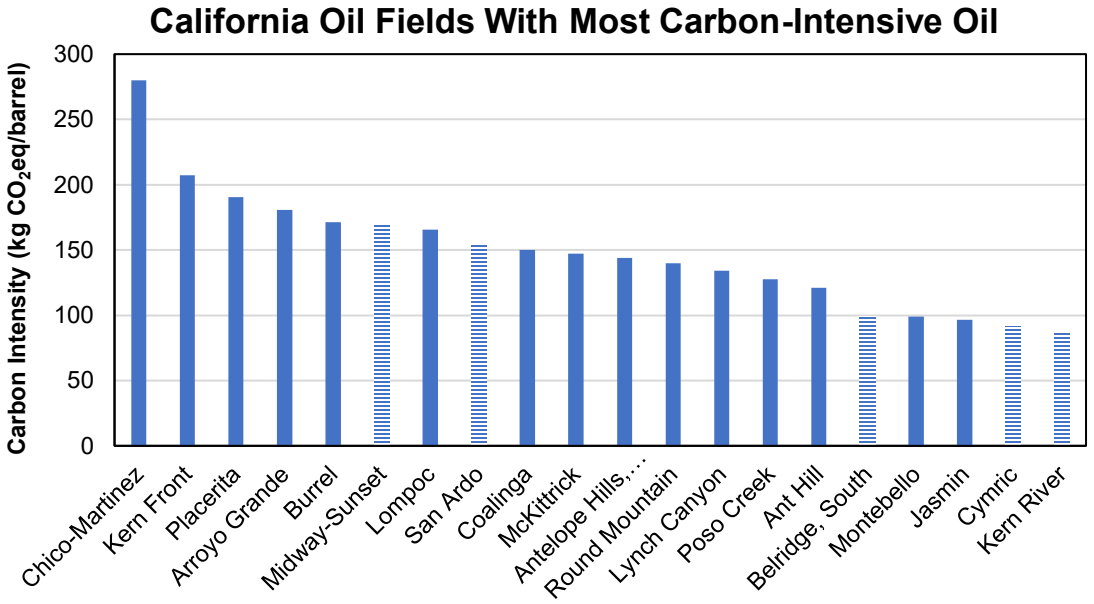
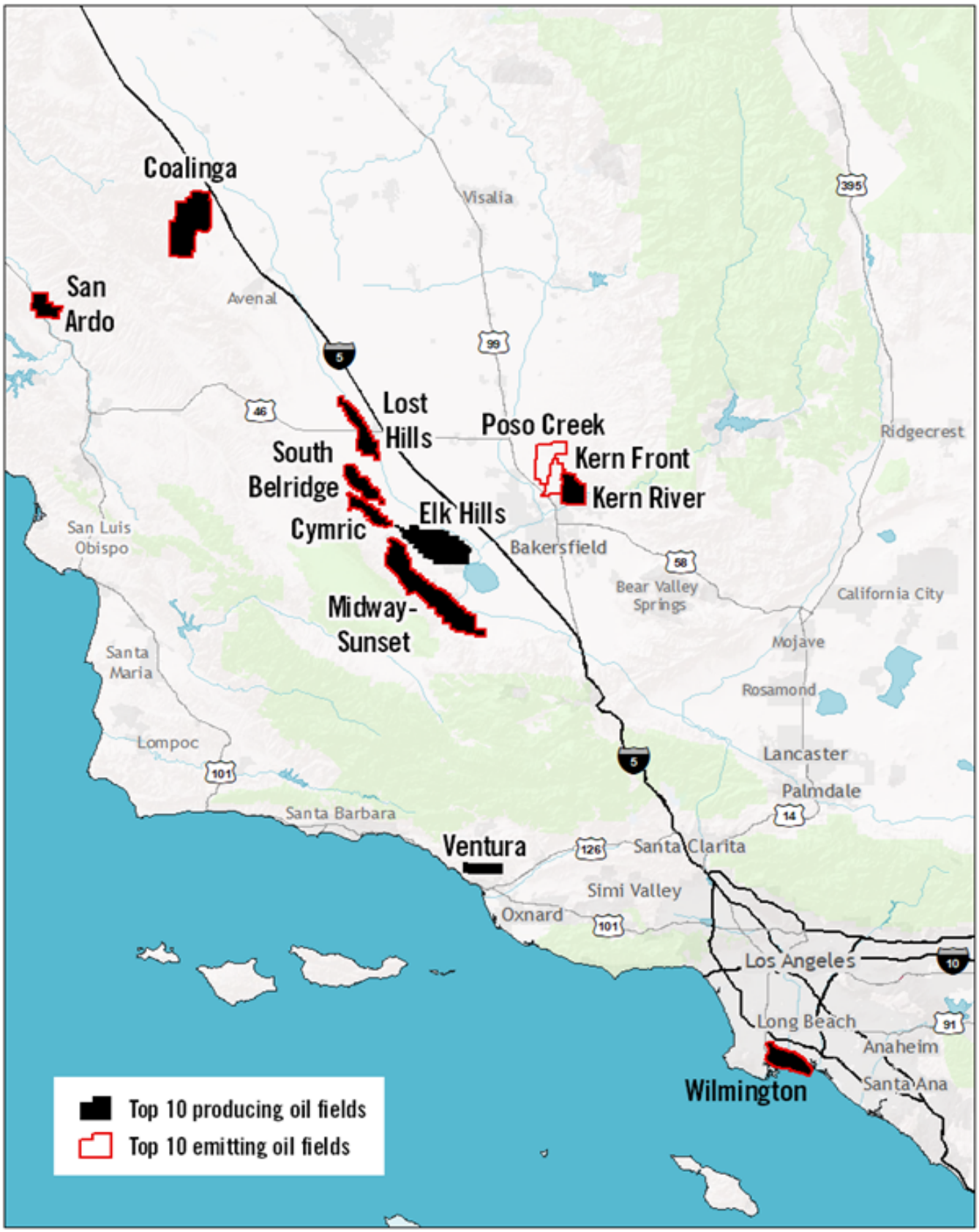


Figure 4: California's top 20 oilfields based on carbon intensity in 2019. The top 5 based on their contribution to the total upstream emissions of California-sourced oils are distinguished with horizontal stripes.

Top 10 Most Productive California Oilfields vs. Top 10 Carbon Dioxide Emitters

It's no surprise that California's top oil-producing fields also tend to contribute the most to California oil's upstream carbon dioxide emissions. Eight of the top 10 emitters are also in the top 10 for oil production. That means the fields producing the most oil also produce some of the dirtiest and most damaging crude, worsening California's overall contribution to dangerous global heating.



California oil is now more carbon intensive than notoriously dirty Canadian tar sands crude.

Our 2017 study found that three quarters of oil produced in California was as climate-damaging as Canadian tar sands crude, which is infamous for being exceptionally dirty.[25] This report shows that California oil has become more carbon intensive since that time.

In 2019 the average upstream carbon intensity of California oil exceeded that of Canadian tar sands crude with about 98 kg CO_2eq/barrel for California oil and about 90 kg CO_2eq/barrel for Canadian tar sands crude refined in California. Moreover, between 2012 and 2019, the average carbon intensity of Canadian tar sands crude refined in California declined, while the average carbon intensity of California-sourced oil increased (Figure 5). This may be due to California refineries refining proportionally less of the dirtiest Canadian oils over time.

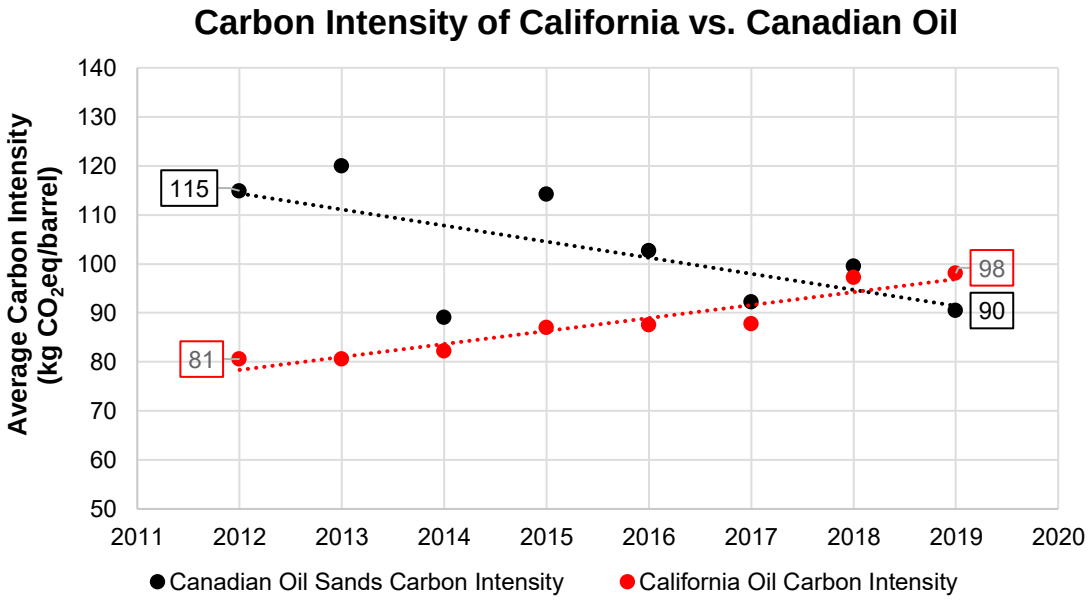


Figure 5: Change in average carbon intensity over time of Canadian oil sands crude vs. California-sourced oil. Here, average carbon intensity and average upstream emissions are interchangeable.

The last point is evidenced by the difference in the range of carbon intensities of Canadian crudes between 2012 and 2019. In 2012, the range was 44 to 142 kg CO_2eq/barrel, whereas in 2019 it was 47 to 171 kg CO_2eq/barrel. Even though the range shifted up in 2019, indicating dirtier oil streams being refined from Canada, the overall average carbon intensity was less in 2019 than in 2012, meaning a smaller proportion of these dirtier oils were refined.


Tar sands in Alberta
by Dru Oja Jay, Dominion

The increase in carbon intensity of California-sourced oils is partially canceling out the benefits of the decline in California oil production.

California's oil production has been in long-term decline since 1985 (Figure 6):

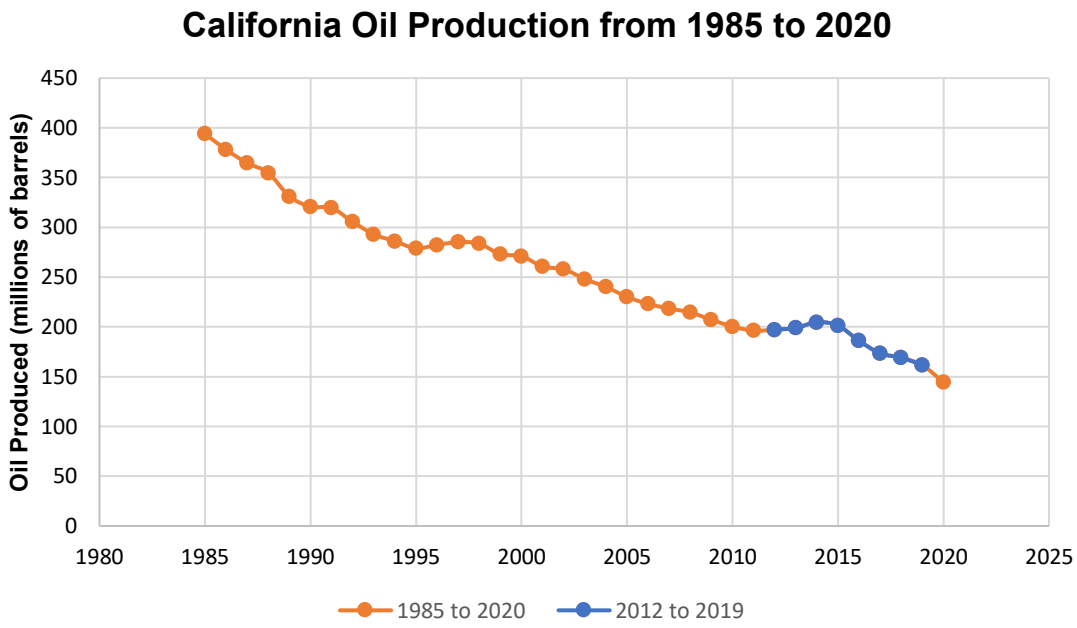


Figure 6: California oil production from 1985 to 2020.[26]

This trend holds in the 2012 to 2019 timeframe of our analysis, with the first three years holding a relatively steady annual amount of oil production, and 2015 to 2019 seeing declines in both oil production and upstream emissions from California-sourced oils (Figure 7).

However, the rate of decline in oil production from 2015 to 2019 exceeded the rate of decline in upstream emissions. While oil production declined by 22% between 2015 and 2019, upstream emissions only declined by 13%. If we compare 2012 and 2019, oil production was 20% less in 2019 than in 2012, whereas upstream emissions were only 3% less. Both cases make clear that the increase in carbon intensity of California-sourced oils is partially canceling out the climate benefits of California's oil-production decline.

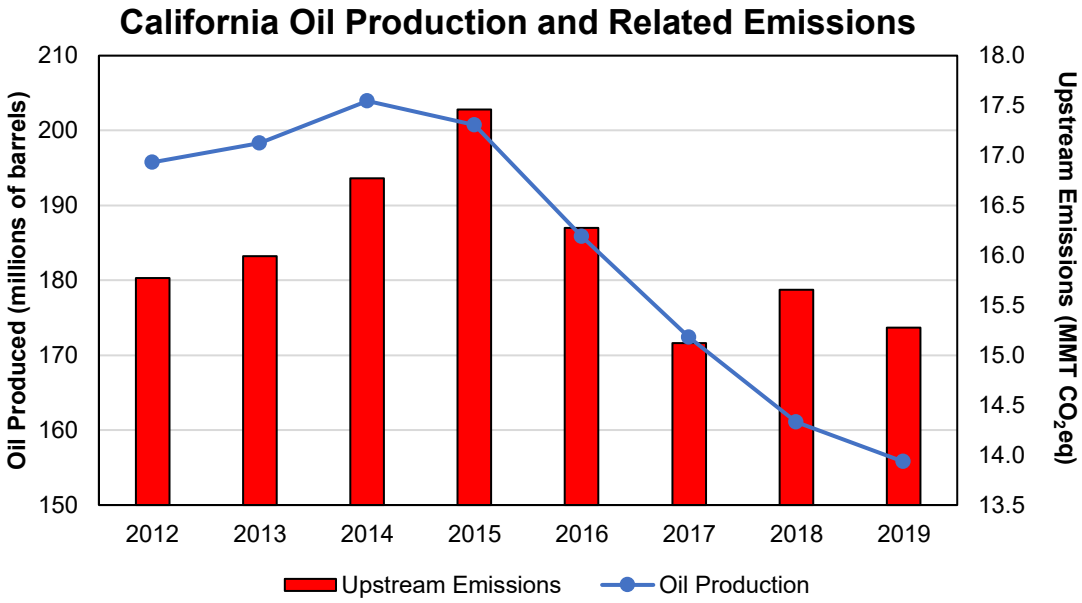


Figure 7: Upstream emissions from California-sourced oils vs. California oil production between 2012 and 2019.

For example, upstream emissions in 2015 were about 18.1 MMT CO_2eq. So if upstream emissions declined by 22% between 2015 and 2019, as oil production did, then emissions in 2019 would be about 14.1 MMT CO_2eq. Instead upstream emissions in 2019 were 15.8 MMT CO_2eq, or about 1.7 MMT CO_2eq more. Assuming this value is 20% of lifecycle emissions (upstream emissions + midstream refining emissions + downstream end use emissions; assumption addressed in more detail in the Discussion), then the lifecycle emissions would be about 8.5 MMT CO_2eq more, or an additional 2% of California's total emissions (based on a 2018 estimate of California total emissions).

Thus, increasing carbon intensity is reducing California's potential progress on reducing greenhouse gas emissions. To maximize emissions reductions, policymakers should both reduce oil production and eliminate enhanced oil-recovery techniques that increase the carbon intensity of California oils.

San Ardo Oil Field by Drew Bird Photography

Discussion

A phaseout of California oil production does not require an increase in imports.

Proponents of business-as-usual oil extraction in California often say that limiting oil production in California will require an increase in imports from parts of the world where oil is produced with fewer environmental safeguards. This is simply incorrect.

A 2018 study found that the decline in production that would result if California stopped approving new oil wells would be approximately equal to the decline in oil consumption forecast by the California Air Resources Board's (CARB's) "Scoping Plan" to reduce greenhouse gas emissions (Figure 8).[27] Ending the approval of new oil wells and accelerating the ongoing decline in the state's oil production would, therefore, not require an increase in imports.

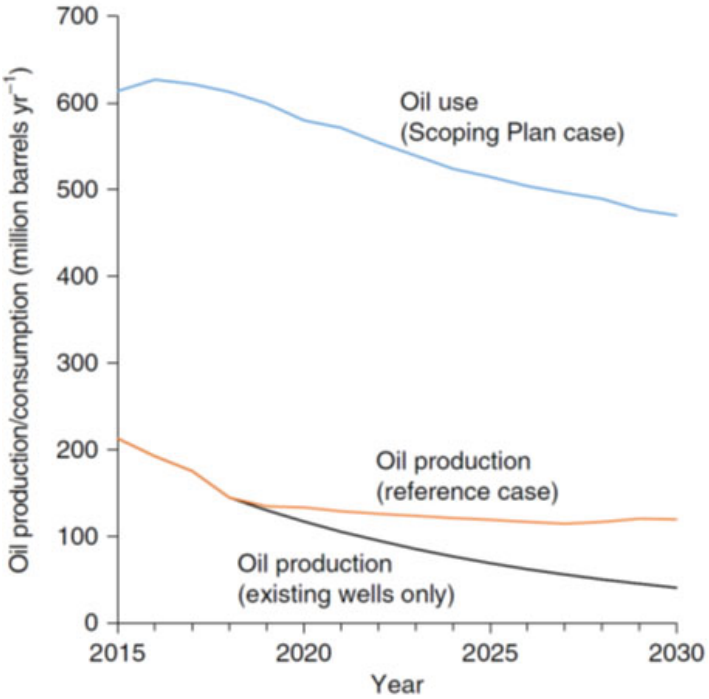


Figure 8: California's projected decline in oil production and consumption. (1) Reference scenario (orange line): developed by the U.S. Energy Information Administration, the state's annual oil production decline trajectory if it continues issuing new drilling permits; (2) No new wells (black line): production drawdown if California stopped issuing drilling permits; (3) Scoping Plan scenario (blue line): estimate of future oil use based on California's Scoping Plan (for gasoline, diesel and liquefied petroleum gas), the federal government (for residual and other oil), and the federal government and the California Energy Commission (for jet fuel). Figure and data from Erickson, P. et al. (2018).[28]

An update to the findings of the 2018 study using data from a 2020 CARB-commissioned study that charted three pathways for California carbon neutrality by 2045 strengthens this conclusion. Under CARB's "Balanced" and "Zero Carbon Energy" scenarios, the decline in California oil demand between 2020 and 2030 would exceed the decline in oil production if the state stopped issuing permits for new oil wells.[29] Thus, under California's current climate policies, California can and should simultaneously reduce in-state oil production and oil imports.

In 2020 oil production in California dropped to 144 million barrels, or by 10.6% compared to 2019.[30] According to state regulators, only 138 new wells were drilled, despite the issuance of permits for nearly 2,000 new wells.[31] Meanwhile, imports dropped by 22% from 616,122 barrels to 485,454 barrels.[32]

These declines are largely because of less oil consumption during the COVID-19 pandemic, but this further emphasizes the point that as California oil demand decreases, declines in production from halting new oil well permits would not need to be compensated for with increases in imports. With decreasing demand, in a no-new-permits scenario, both production and imports would decline, leading to a global decline in fossil fuel reliance.

However, research by Communities for a Better Environment reveals a troubling trend: In recent years California refineries have increased their production of gasoline for *export* to Pacific Rim countries, maintaining demand for imports despite falling oil use within the state.[33] If California allows this trend to continue, then it will continue to prop up imports. This emphasizes the need for the state to pursue a just transition that winds down all phases of the fossil fuel lifecycle, including refining.

A phaseout of oil extraction in California would not only get rid of an exceptionally dirty source of crude, but it would also lead to an overall global reduction in oil production and decrease in global carbon emissions. This is because every barrel of California oil left in the ground will reduce overall oil supply, resulting in a net decrease of about half a barrel of oil consumption globally.[34] Thus, actions taken in California to curb oil production will have global ramifications.

California's oil and gas regulatory failures have worsened the state's public health and environmental justice crises.

The oil industry's argument that production limits here will cause more production in places with weaker environmental safeguards is not only wrong, but also morally reprehensible because it minimizes California's regulatory failures and the public health and environmental justice crises caused by in-state oil production.

California's long-term regulatory failures are shocking and include the following:

- California is virtually the only major oil-producing state with no minimum setback distance between wells and homes, schools or other sensitive receptors, despite the grave health harms from oil and gas pollution.
- An EPA audit in 2011 found widespread failures in enforcing state regulations pertaining to the safety of oil and gas-related underground injection projects.[35]
- The California Geologic Energy Management Division (CalGEM) admitted in 2015 that thousands of oil and gas wells were improperly injecting wastewater into California's protected underground sources of drinking water, leading to the widespread contamination of the state's water supplies.[36] Half a decade later, the state has reneged on multiple commitments to remedy the situation and our water supplies are still being sacrificed to the oil industry.[37]
- California's lax waste-disposal laws allow oil industry wastewater to be dumped into unlined pits, which has led to multiple additional instances of groundwater contamination.[38]
- Loosening regulations on steam injection pressure led to multiple large-scale spills in Central California in 2019. CalGEM has yet to collect any fines for a 1.3-million-gallon spill in the Cymric oilfield,[39] and a separate spill of over 4 million gallons is still ongoing.[40] These spills contaminate the environment and threaten wildlife.
- Reports uncovered that multiple regulators had financial interests in oil companies,[41] and numerous top agency officials have gone on to work for the industry.
- Dozens of injection projects were approved under "dummy" files that had no underlying review for the project.[42]
- CalGEM has brought virtually no enforcement actions in response to illegal pollution.[43]
- CalGEM also has failed to comply with the environmental review and public participation requirements of the California Environmental Quality Act, despite acknowledging the environmental harms of extraction.[44]

California's regulatory record on oil and gas does not justify claims that it has the toughest environmental regulations in the world. On the contrary, it highlights the urgent need to phase out dangerous and dirty fossil fuel production in the state.

Lifecycle emissions make California oils' climate harms even more pronounced.

The carbon intensity values provided by the Air Resources Board only consider upstream emissions from oil, or the emissions from extracting and transporting oil up to the refinery gate. However, every step of the fossil fuel life cycle produces greenhouse gas pollution, including midstream refining and downstream combustion.

While we take comparisons of the upstream data from CARB as representative of the relative "dirtiness" of different oils refined in California, the overall climate impact of oils refined in California depends on the total lifecycle emissions. The emissions from midstream and downstream processes typically exceed upstream emissions. This is apparent when considering previously reported lifecycle emissions of California's top five oils in terms of upstream emissions — Midway-Sunset, South Belridge, Cymric, Kern River and San Ardo (Table 2):[45]

Field	2017 Upstream Emissions ($kg CO_2eq/bbl$)	2017 Lifecycle Emissions ($kg CO_2eq/bbl$)	% Upstream Emissions
Midway-Sunset	146	725	20%
South Belridge	86	690	12%
Cymric	112	600	19%
Kern River	56	650	9%
San Ardo	159	760	21%

Table 2: For California's top oilfields in terms of upstream emissions, listed are the upstream emissions estimates from 2017, most recent lifecycle emissions estimates from 2017, and upstream emissions per barrel as a percentage of lifecycle emissions per barrel.

Comparing the 2017 (the year with the most recent lifecycle emissions data) upstream and lifecycle emissions of the top five fields, we find that midstream and downstream processes constitute a greater proportion of emissions than upstream processes. Taking the above five fields as an example, upstream emissions are most often around 20% of the total lifecycle emissions. This agrees with an estimate by the Stockholm Environmental Institute in which factoring in upstream emissions increases the total emissions per barrel of oil by at least 25%,[46] which would likewise make upstream emissions about 20% of the total.

Putting this into perspective, California's total CO_2eq emissions across all sectors in 2018 was 425 MMT CO_2eq. In just 2018, upstream emissions from California-sourced oil were about 16 MMT CO_2eq. Assuming upstream emissions are about 20% of total lifecycle emissions, lifecycle emissions from California-sourced oil in 2018 would be about 80 MMT CO_2eq, which would make them almost 20% of California's total emissions in 2018 (Table 3).

Year	Oil Production (bbl)	Upstream Emissions (MMT CO_2eq)	Lifecycle Emissions (MMT CO_2eq)	Total CA Emissions (MMT CO_2eq)	% Upstream Emissions	% Lifecycle Emissions
2012	196	15.8	78.9	451.6	3.5%	17%
2013	198	16.0	80.0	447.6	3.6%	18%
2014	204	16.8	83.9	443.4	3.8%	19%
2015	201	17.5	87.3	440.8	4.0%	20%
2016	186	16.3	81.4	429.2	3.8%	18%
2017	172	15.1	75.6	424.5	3.6%	18%
2018	161	15.7	78.3	425.3	3.7%	18%
2019	156	15.3	76.4	--	--	--

Table 3: For the years 2012 to 2019, listed are barrels of California oil production, estimated California upstream emissions, estimated lifecycle emissions assuming upstream emissions are 20% of lifecycle emissions, and total California emissions across sectors. Using those values, upstream and lifecycle emissions as a percentage of total California emissions were calculated and listed.

The importance of considering lifecycle emissions is even more apparent when looking at the carbon intensity of California's refining itself. As follows from California both producing and accepting some of the dirtiest oil for refining, California's refining processes are exceptionally dirty.

Because California refines the heaviest crude on average, California refineries emit more CO_2eq per barrel of crude refined than those in any other major U.S. refining region. For 2013 to 2017, the average carbon intensity of California refining was 59.3 kg CO_2eq/barrel, whereas the U.S. average over the same time was 49.3 kg CO_2eq/barrel. Some individual refineries in California have refining carbon intensities as high as 79 kg CO_2eq/barrel.[47]

California-sourced oil's excessive upstream emissions burden not only California's population but the entire planet with some of the world's dirtiest refining.

California's Gas Production is More Climate-Damaging Than Coal And Threatens Public Health and Safety.

While California is the seventh-largest oil producer and third-largest oil refiner, it ranks 14th in U.S. fossil gas production, with nearly 200 billion cubic feet produced in 2019. California's gas production, however, is also exceptionally dirty, dangerous and carbon intensive.

A recent report from the California Energy Commission assumes fossil gas as part of California's energy mix well into the future, treating it as a bridge fuel. However, methane — a superpollutant 87 times more powerful than CO2 at warming the climate over a 20-year period — leaks during all phases of oil and gas production.

If the methane leakage rate is greater than 2.4% of the gas produced, then the climate damage from the methane leakage cancels out any climate benefit that gas achieves over coal at the smokestack over a 20-year period.

Therefore, depending on the overall leakage rate, fossil gas provides little or no climate benefit over coal: In fact, fossil gas may even be worse.

A recent analysis found that the methane leakage rate in the San Joaquin Valley is 4.8%, making gas sourced from this region not only worse than coal on a 20-year timescale, but also the worst in the continental United States.

In addition to its role as a major climate pollutant, gas production also threatens public health and safety. The 2015 gas leak disaster at the Aliso Canyon gas storage facility near Los Angeles resulted in 109,000 metric tons of methane entering our atmosphere—the largest-known methane release in U.S. history.

The Aliso Canyon disaster boosted statewide greenhouse gas emissions, set back emissions-reduction goals and sickened nearby residents with symptoms including dizziness, headaches, nausea, eye, nose and throat irritation, nose bleeds and likely long-term effects yet to be identified. Clearly the risks of keeping gas infrastructure in place far exceed any benefits.

Though California's dirty oil is the focus of the present study, it must be considered in the context of California's overarching dirty fossil fuel industry. The continued extraction of both exceptionally dirty oil and gas only makes a stronger case for the rapid phaseout of fossil fuels to mitigate substantial climate and public health harms.

Conclusion

Because climate change is driven primarily by fossil fuel production and combustion, most of the world's fossil fuels must stay in the ground to avoid the worst dangers of climate change. Worldwide, there are more than enough fossil fuels in already developed production fields to far exceed targets to limit warming to 1.5 degrees C or even 2 degrees C.[48] New fossil fuel development and infrastructure is thus unsafe and unjustified, and fossil fuel production must be phased out globally within the next several decades. With one of the world's wealthiest economies and some of the world's dirtiest oil, California needs to lead the way in ending fossil fuel production.

To address the climate damage, health harms and environmental injustice caused by its increasingly dirty oil production, Gov. Newsom should direct his regulators to end approvals for new oil and gas wells and other fossil fuel projects and commit to a plan to phase out existing extraction far faster than 2045. Newsom should also act now, not in 2024, to ban fracking and related extreme techniques that amplify the damage from extraction. Newsom should immediately implement a health-and-safety buffer to prevent oil and gas drilling in communities and protect public health and safety from the air pollution and other harms of oil and gas extraction. Without taking these crucial steps, California cannot protect the climate or the state's most vulnerable communities.

Inglewood Oil Field by Gary Kavanagh

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Appendix

California-sourced oil is the primary contributor to the average carbon intensity of all oil refined in California.

Although California oil was about 31% of all oil refined in California between 2012 and 2019, it was responsible for about 39% of the carbon intensity, or about 39% of the emissions leading up to the refinery gate (upstream emissions).

Calculated using the carbon intensity values provided by CARB, it is estimated that upstream emissions of oils refined in California between 2012 and 2019 were about 343 million metric tons CO_2eq (MMT CO_2eq). It follows that oil not produced in California constituted about 69% of all oil refined in California but was responsible for only 61% of the emissions leading up to the refinery gate.

As a reference, if all oils refined in California had the same carbon intensity, then their contribution to the total emissions leading up to the refinery gate would be the same as their contribution to the total volume of oil refined in California. So, a contribution to the carbon intensity that is more than the contribution to total oil refined indicates a carbon intensity above the overall average. In turn, a contribution to the carbon intensity that is less than the contribution to the total volume of oil refined indicates a carbon intensity below the overall average. This further indicates that, on average, California oil is more polluting per barrel than the rest of the global supply refined in California.

This fact holds when considering just the oil produced in the U.S. that is refined in California. Oil produced in the U.S., including oil produced in California, constitutes 46% of the oil refined in California, but 54% of the upstream emissions. However, if broken down further, oil produced in the U.S. *excluding* oil produced in California constitutes 15% of the oil refined in California but 16% of the upstream emissions.

In other words, the contribution of U.S. oil, including California, to upstream emissions is 1.2 times its contribution to the total production. The contribution of U.S. oil, excluding California, to upstream emissions is 1.05 times. And the contribution of California oil to the total upstream emissions is 1.3 times its contribution to the total production. So, normalized to production, oil produced in California contributes more to the upstream emissions for California-refined oils than other U.S. oils (Figure 9).

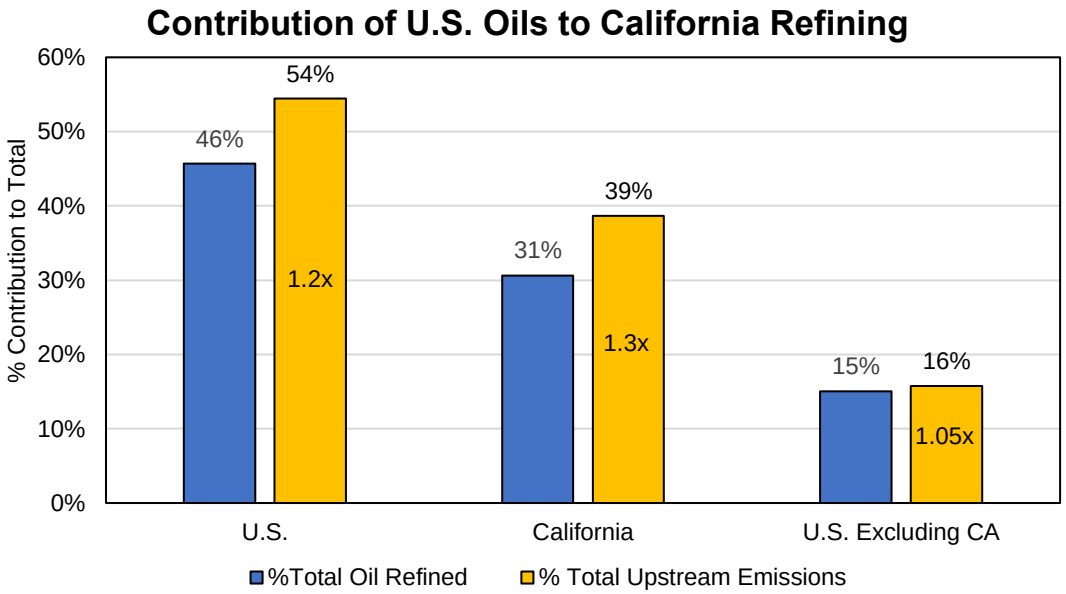

Figure 9: For U.S.-sourced oil including California, California-sourced oil, and U.S.-sourced oil excluding California, the volume of oil as a percentage of all oil refined in CA (% Total Oil Refined) vs. oil as its percent contribution to the total upstream emissions of all oil refined in CA (% Total Upstream Emissions). Also labeled on the orange bars is the multiple by which a given region's contribution to the total upstream emissions compares to its contribution to the total oil refined. Here, the contribution to average carbon intensity and the contribution to upstream emissions are interchangeable.

There is strong overlap between California fields employing enhanced oil recovery techniques and those with the most upstream emissions.

Enhanced oil recovery techniques such as cyclic steam and steamflooding are known to be energy-intensive compared to conventional oil extraction with the result being greater associated greenhouse gas emissions. In California, 19 fields have cyclic steam wells (Figure 10) while 18 fields have steamflood wells (Figure 11), with significant overlap of the two groups.

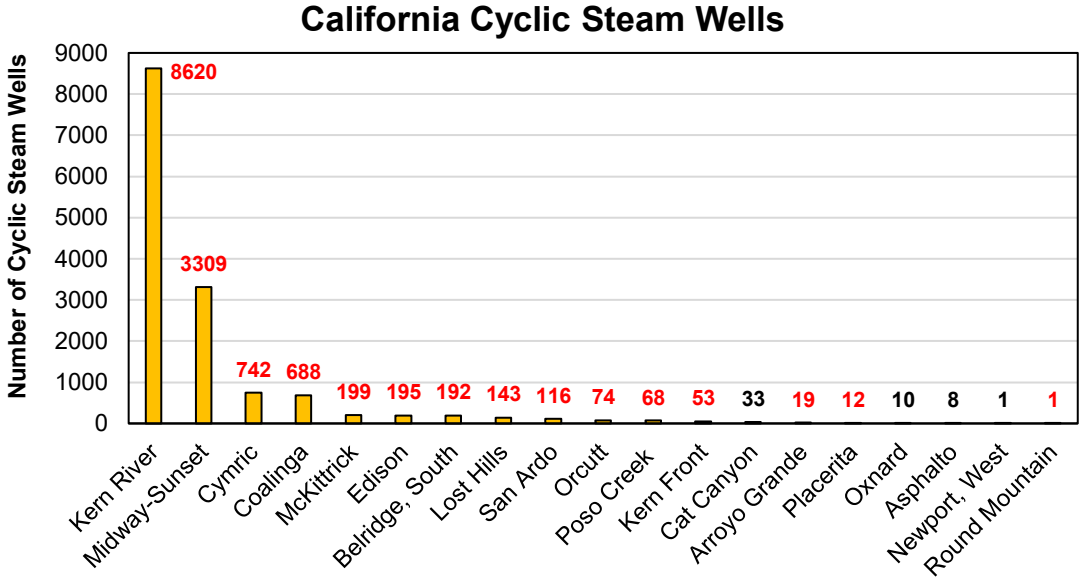

Figure 10: Cyclic steam wells in California based on 2020 data. The number of cyclic steam wells in each oilfield is labeled. The oilfields that are also in the top 20 for upstream emissions have red labels.

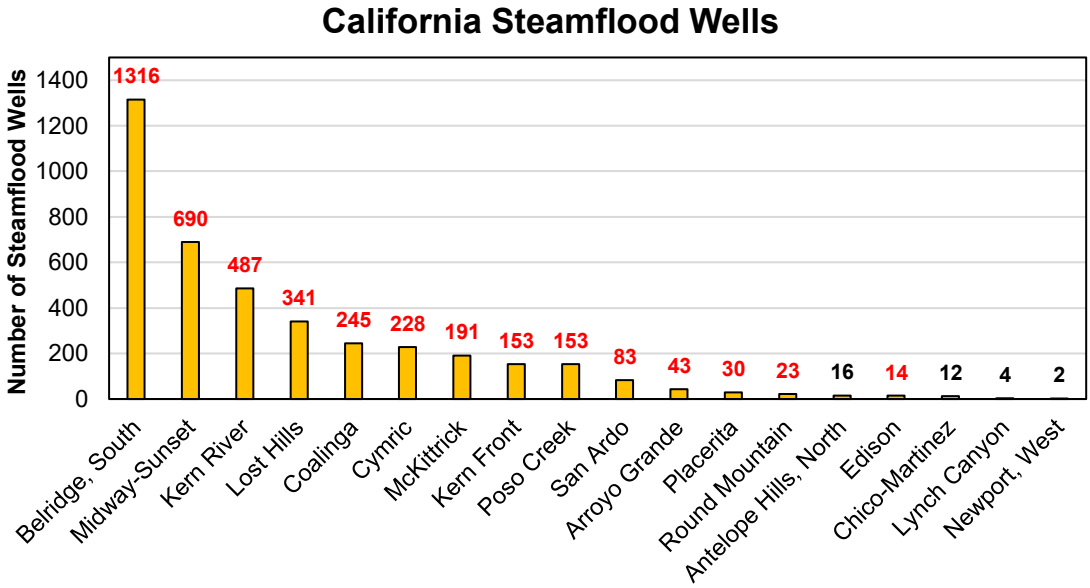

Figure 11: Steamflood wells in California based on 2020 data. The number of steamflood wells in each oilfield is labeled. The oilfields that are also in the top 20 for upstream emissions have red labels.

Notably, of the 19 oilfields with cyclic steam wells, 15 rank in the top 20 for their contribution to upstream emissions from California-sourced oils. Of the 18 oilfields with steamflood wells, 14 rank in the top 20 for their contribution to upstream emissions. Also, four of the top five oilfields in terms of upstream emissions rank highly in terms of numbers of steam wells: Kern River, Midway-Sunset, and Cymric are 1, 2, and 3, respectively, for number of cyclic steam wells while South Belridge, Midway-Sunset, and Kern River are 1, 2, and 3, respectively, for number of steamflood wells. The top five oilfields for upstream emissions (the four mentioned, plus San Ardo) together have 70% of California's steamflood wells and 90% of California's cyclic steam wells, or 85% of California's total steam wells (cyclic steam + steamflood).

There is significant overlap in California between fracking permits, enhanced oil recovery and the most carbon-intensive oil extraction.

In 2020, 1,929 oil and gas drilling permits were issued in California with 1,052 of them, or 55%, going to the top five fields contributing the most to greenhouse gas emissions. Of the top five fields, South Belridge received the most with 351, then Midway-Sunset with 346, Cymric with 221, Kern River with 111 and San Ardo with 23.

Of the total permits, 1,359 were for oilfields in the top 20 for carbon intensity (Figure 6).

Finally, of the total permits, 65 were for cyclic steam wells and 64 were for steamflood wells. Out of the 129 total cyclic steam and steamflood well permits, 78 permits, or 60%, were for fields in the top five for greenhouse gas emissions.

In 2020, 84 permits for fracking were issued with 24, or 29%, for South Belridge. Another 36, or 43%, were issued for Lost Hills Oil Field. Lost Hills has not been previously mentioned, but it is noteworthy as number seven in terms of oilfield greenhouse gas emissions. The remaining permits were granted to North Belridge which is number 22 in terms of oilfield greenhouse gas emissions.

As is the case with existing enhanced oil recovery wells, the oilfields being granted oil and gas drilling and fracking permits are those that already contribute the most to California oil's greenhouse gas emissions, hence maintaining a vicious cycle.