PETROLEUM WATCH

CALIFORNIA ENERGY COMMISSION

INSIDE

REFINERY NEWS

- **Kern Oil:** On April 8, a heater fire occurred at the refinery due to unknown reasons (California Governor's Office of Emergency Services).
- **Chevron Richmond:** On April 22, the Bay Area Air Quality Management District (BAAQMD) announced that Chevron USA Inc. agreed to pay $146,500 to settle air quality violations in Richmond (BAAQMD).
- **Marathon Martinez:** On April 27, the refinery temporarily idled due to demand concerns resulting from COVID-19 (Reuters).

CALIFORNIA GASOLINE RETAIL PRICES BY BRAND

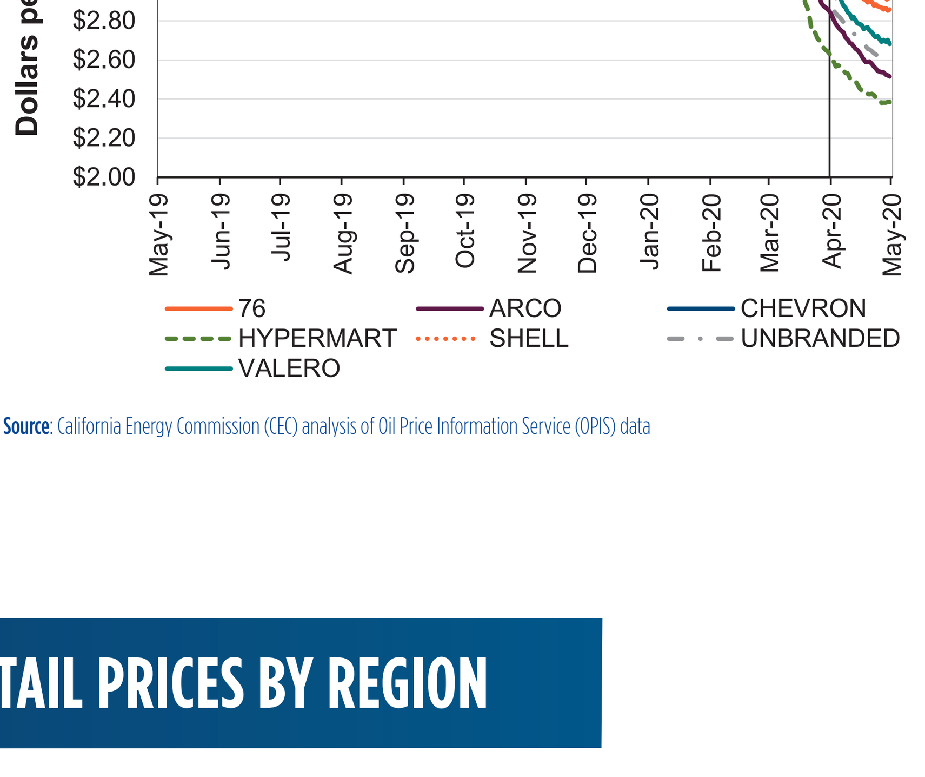
April 2020 vs. 2019

(Percentage Change)

76	26% lower
ARCO	30% lower
Chevron	26% lower
Hypermart	33% lower
Shell	26% lower
Unbranded	29% lower
Valero	28% lower

April 2020 Averages

76	$2.95
ARCO	$2.64
Chevron	$3.02
Hypermart	$2.47
Shell	$3.00
Unbranded	$2.71
Valero	$2.80



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

CALIFORNIA DIESEL RETAIL PRICES BY REGION

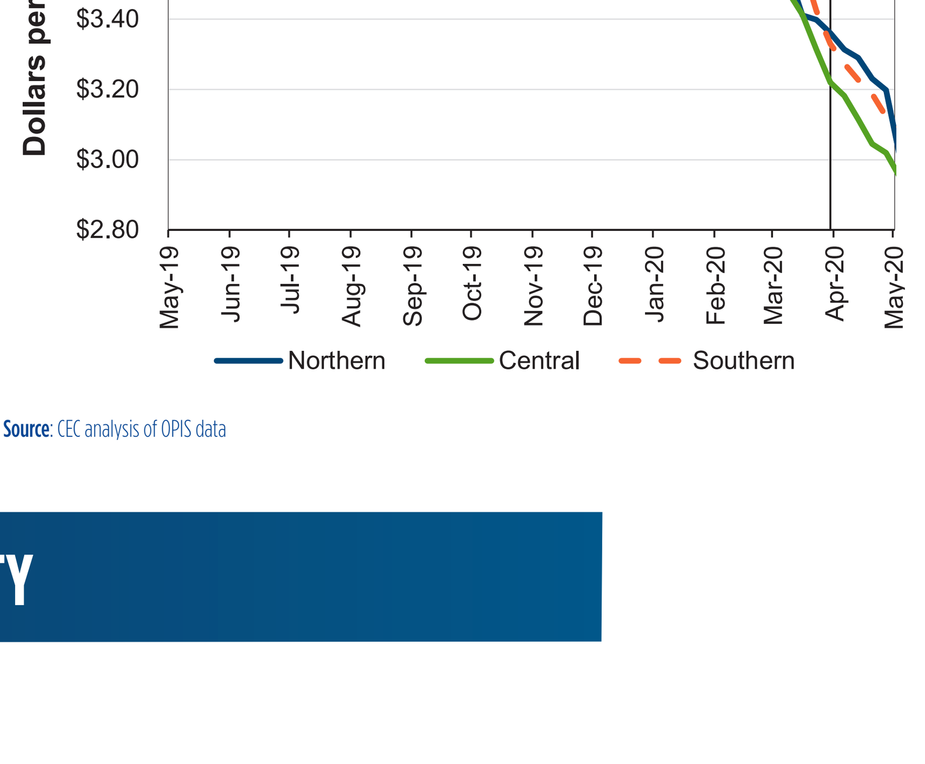
April 2020 vs. 2019

(Percentage Change)

Northern CA	18% lower
Central CA	20% lower
Southern CA	18% lower

April 2020 Averages

Northern CA	$3.28
Central CA	$3.11
Southern CA	$3.23

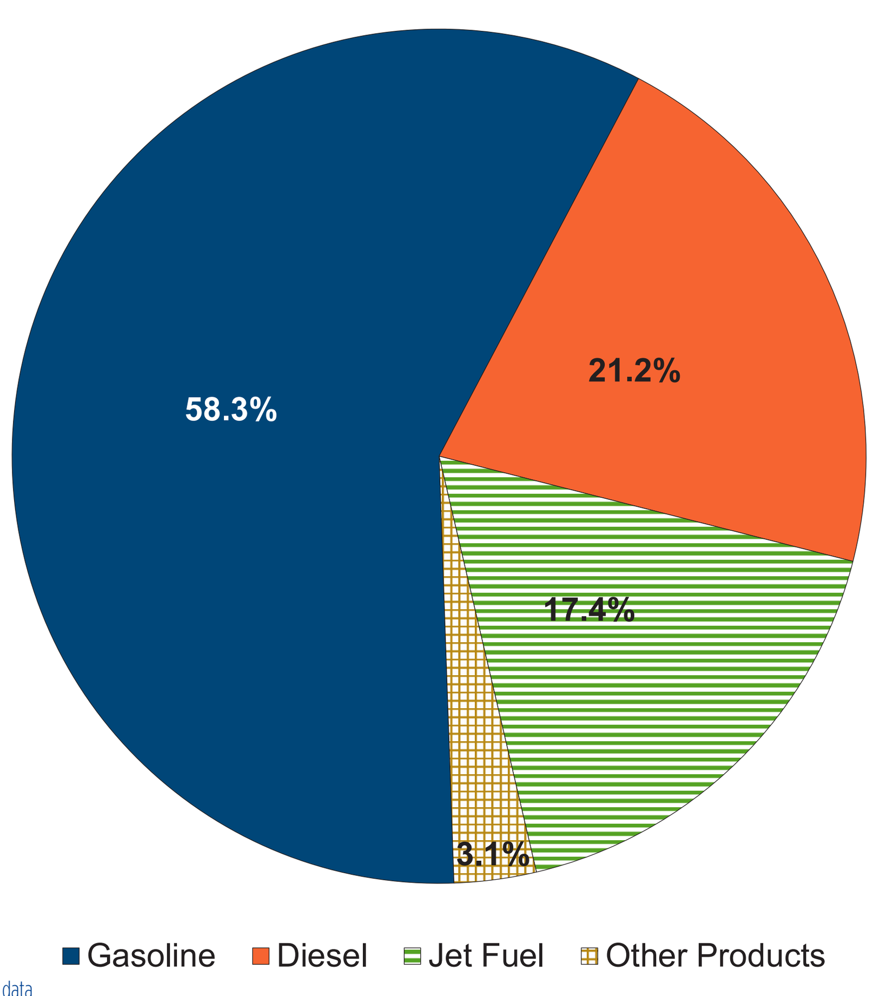


Source: CEC analysis of OPIS data

DOWNSTREAM CAPACITY

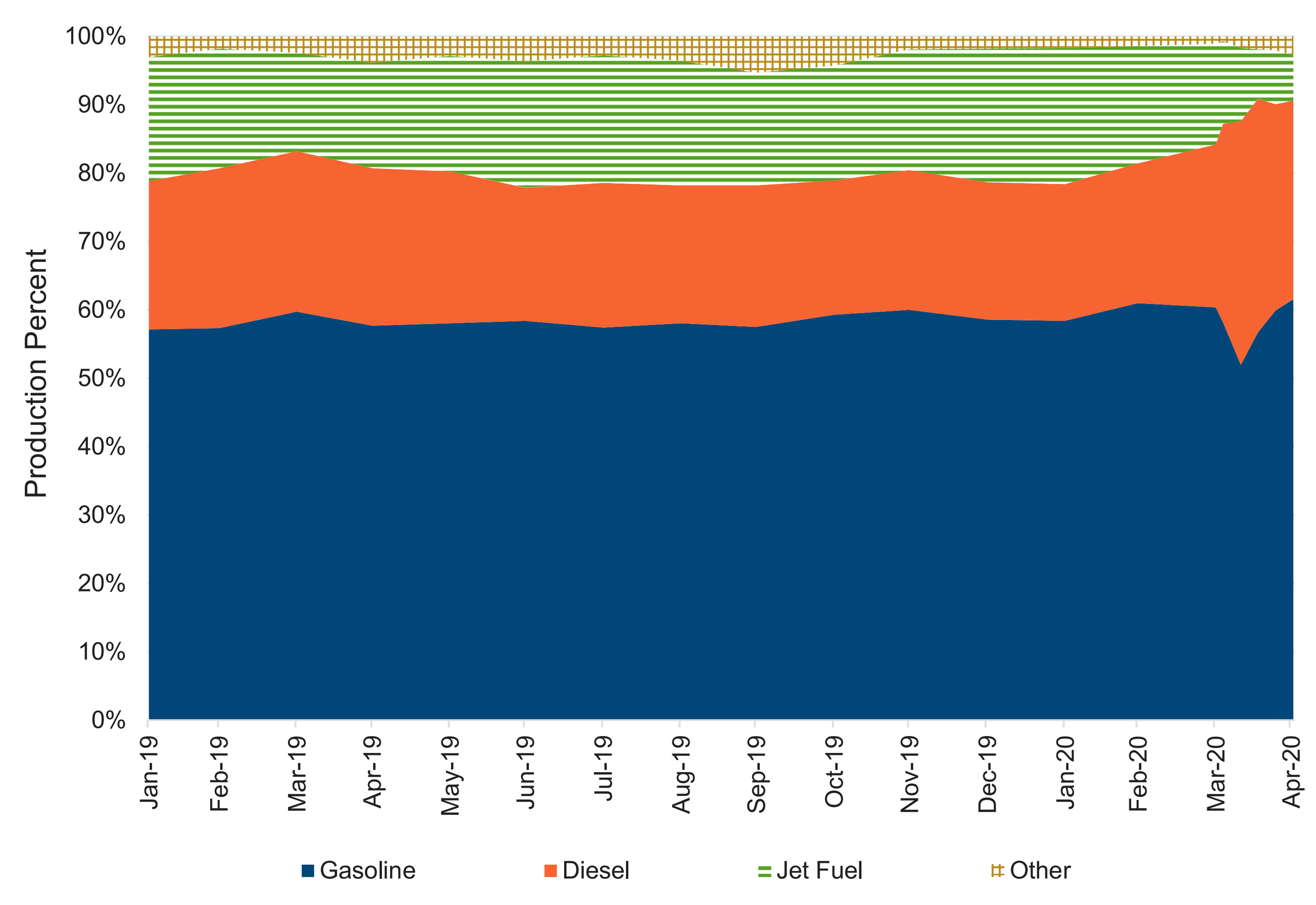
Notes: PADDs are geographic aggregations: PADD 1 is the East Coast, PADD 2 is the Midwest, PADD 3 is the Gulf Coast, PADD 4 is the Rocky Mountains, and PADD 5 is the West Coast. States with total crude capacity greater than 500,000 barrels per day were used in this analysis. PADD 4 does not contain any states that meet this requirement so it has been omitted from the data.
Source: CEC analysis of U.S. Energy Information Administration (EIA) data

CALIFORNIA REFINERIES 2019 NET PRODUCTION



Source: CEC analysis of CEC and EIA data

PRODUCTION SHARE OF REFINED PRODUCTS

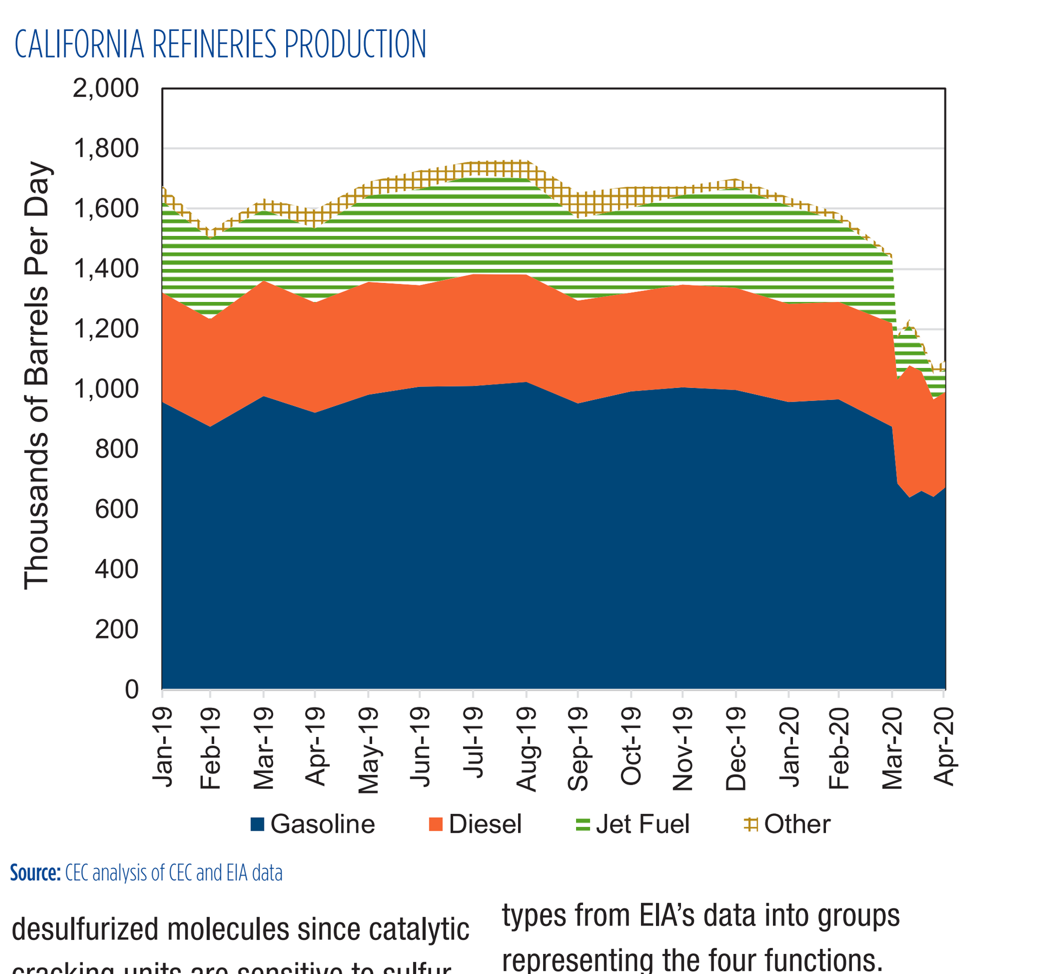


Source: CEC analysis of CEC and EIA data

FEATURED TOPIC

REFINING OPERATIONS UNDER DECREASED DEMAND

CALIFORNIA REFINERIES PRODUCTION



Source: CEC analysis of CEC and EIA data

DEMAND DECLINE

Refineries in California face an unprecedented decrease in product demand. Refinery operators have responded by decreasing production and altering finished product output where possible as shown in California Refineries Production. For the week ending on May 1, crude input for California refineries decreased by 34.3 percent from a year ago, while gasoline production is down 31.2 percent, jet fuel is down 71.7 percent, and diesel is down 10.5 percent. In addition, gasoline inventories are at their highest level in five years. One of California's 11 major refineries, Marathon's Martinez refinery, responsible for nearly 8.5 percent of California's total refining capacity, went idle on April 27, an indication of the unprecedented lack of demand.

Refineries are designed and built with the crude oil input and product output in mind. While there is some room for adjustment, much of the process is dictated by the tolerances of existing equipment. Crude distillation depends on the composition of the crude oil input. All other units, except distillation, are downstream units that allow refiners greater control of final products.

REFINERY PROCESSES

Oil refineries convert the mixture of hydrocarbon molecules from crude oil into refined products that people use, like gasoline and diesel. Refineries use large processing units for four major functions: sorting, breaking, rearranging, and cleaning. Some processing units need catalysts, like platinum or sulfuric acid, to react with the unrefined oil. Nearly all the units operate by changing temperature, pressure, and the movement of fluids. The sorting units is the first stage at most refineries.

Sorting

Sorting units separate the heavy hydrocarbon molecules from the lighter molecules.

The crude distillation unit, or crude unit, is the primary sorting unit and the centerpiece of most refineries. By boiling the crude oil, the unit separates the crude into light and heavy hydrocarbons: gasses (e.g., propane), gasoline, jet fuel, and diesel. Refineries are boiling the crude without burning it, leaving the bottom of the crude distillation unit with heavy unsorted hydrocarbons.

A secondary distillation unit, the vacuum distillation unit, takes the heavy oils and remaining material, commonly referred to as the bottoms, from crude units and boils them again at a lower pressure to expand the sorting process. The resulting products are called gas oils and are heavier than diesel. Gas oils are too heavy for everyday use and are refined further using breaking processes.

Breaking

Breaking units, or cracking units, crack very heavy molecules into lighter ones. Thermal cracking uses extreme heat. Catalytic cracking uses catalysts to speed up the process. California refineries use three types of breaking processes: hydrocracking, catalytic cracking, and coking.

Hydrocracking units take gas oils, add hydrogen and metal catalyst at high temperature and pressure to break gas oils up into mainly diesel and jet fuel-sized molecules. As a bonus, hydrogen attaches to sulfur, allowing input of dirtier gas oils while producing cleaner outputs.

Fluid catalytic cracking units, or cat crackers, use specialized catalysts to break gas oils into mainly gasoline and lighter molecules with higher octane ratings. This unit is fed only desulfurized molecules since catalytic cracking units are sensitive to sulfur.

Coking units, or cokers, take the bottoms of the vacuum distilling and cracking processes and bakes them at extreme temperatures. This destroys some oil and produces carbon coke. The result is more gas oil to feed downstream cracking units. Thermal crackers, cokers included, use the higher temperatures that the distillation units avoid, because the carbon coke fouls the distillation units. In a coker, the coke is cleaned out and sold as fuel or as precursor for steel and aluminum industries.

Rearranging

Rearranging units focus on gasoline by combining light molecules and reshaping them into complex molecular shapes. This adds desirable qualities like high octane ratings.

Alkylation and polymerization units, or alky and poly units, take light molecules such as butane and combine them into heavier gasoline molecules. Alkylation is a newer process using an acid catalyst which allows a wider range of light and gasoline molecules to combine.

The isomerization unit, or iso unit, converts straight-line shaped molecules into branched shapes of the same weight. The resulting hydrocarbons usually have higher octane ratings.

The catalytic reforming unit, or cat reformer, converts low-quality (low octane) gasoline into higher quality by rearranging the molecules using a catalyst. As a side effect, the unit generates some light hydrocarbons, like methane, and splits off extra hydrogen. The hydrogen becomes feed for cleaning (hydrotreating) and breaking units.

Cleaning

Cleaning units remove sulfur, metals, salts, and other non-hydrocarbons out of the crude oil mixture. Sulfur forms compounds in hydrocarbons that are corrosive, explosive, and dangerous in downstream units and create acid rain when burned in fuel.

Hydro-desulfurization units, hydrotreaters, use a process similar to hydrocracking, but leave molecules unbroken since only sulfur is removed. These units can be used to clean feeds like gas oil headed to cat crackers or for cleaning gasoline, diesel, and jet fuel, before sale.

MEETING ALTERED DEMAND

Engineers and analysts look at downstream unit capacity to project fuel production and find ways to shift production of fuels in emergencies. Units are limited by the capabilities of other units. For example, all units depend on the crude unit, since this is the only unit that can process raw crude oil. Therefore, the capacity of the refinery is limited by the crude unit. Similarly, every cracking unit is limited by the capacity of the vacuum distillation unit. Downstream units and capacities for each refinery in the United States are collected by the EIA.

California Energy Commission staff combined the diverse unit types from EIA's data into groups representing the four functions. Sorting is represented by vacuum distillation. Breaking is represented by thermal cracking (includes coking) and catalytic cracking (combines hydro and cat cracking). Rearranging is represented by combining reforming, polymerization, and alkylation. Cleaning is represented by mid-stage hydrotreating and end-product hydrotreating. To create these groupings, a downstream unit's capacity is calculated as a percentage of the crude distillation unit capacity.

Downstream Capacity shows the percentage of downstream capacity for units in the U.S., PADDs, and states. Only states with a total crude capacity greater than 500,000 barrels per day were included in the analysis. These percentages offer a view of what a refiner expects after they have run the crude unit. The area and shape show how much refineries rely on certain processes. States with simple refineries will cast a narrow small shape, while states with large complex refineries cast a wide large shape.

California's refineries have intensive downstream refining versus the United States in every category but end-product hydrotreating. California refiners have a higher mid-stage hydrotreatment percentage. California's vacuum distillation and thermal cracking percentages are higher against the U.S. total, 62 percent against 47 percent, and 25 percent against 15 percent, respectively. These units work on the heavy products, meaning that California refineries are refining crude oils expecting as much as 62 percent as atmospheric bottoms to be sent to vacuum distillation (32 percent more than what an average national refiner deals with) and expecting a further 25 percent as vacuum bottoms to be sent to thermal cracking (66 percent more than the national profile). The higher volume of vacuum bottoms may be driving the need for California's intensive mid-stage hydrotreatment, which produce gas oils that require cleaning after coking is completed.

DECREASED PRODUCTION LEVELS

California's Refineries 2019 Net Production shows that 58.3 percent of the state's production is gasoline. Diesel and jet fuel account for 21.2 percent and 17.4 percent of the slate, respectively. Production Share of Refined Products shows how the percentage of refinery products changed in April. This chart displays monthly data through March 2020 and uses weekly data for April 2020 to better illustrate the production shifts. Even though crude oil input was down by a third, gasoline never dropped below 50 percent of total production. By April 17, diesel production increased to 34.2 percent, while jet fuel dropped to 7.2 percent. California refineries are currently built to produce gasoline. California refineries can increase diesel production, but at the expense of jet fuel. Compared to other regions, California's more complex refineries may be more flexible and better situated to handle this change in demand.

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