PETROLEUM WATCH

CALIFORNIA ENERGY COMMISSION

INSIDE

REFINERY NEWS

- **PBF Torrance:**
  On October 18, a pipe failed, leaking isobutane, propane, with trace amounts of modified hydrofluoric acid around the alkylation unit at the refinery, according to California Office of Emergency Services (Cal OES).

CALIFORNIA GASOLINE RETAIL PRICES BY BRAND

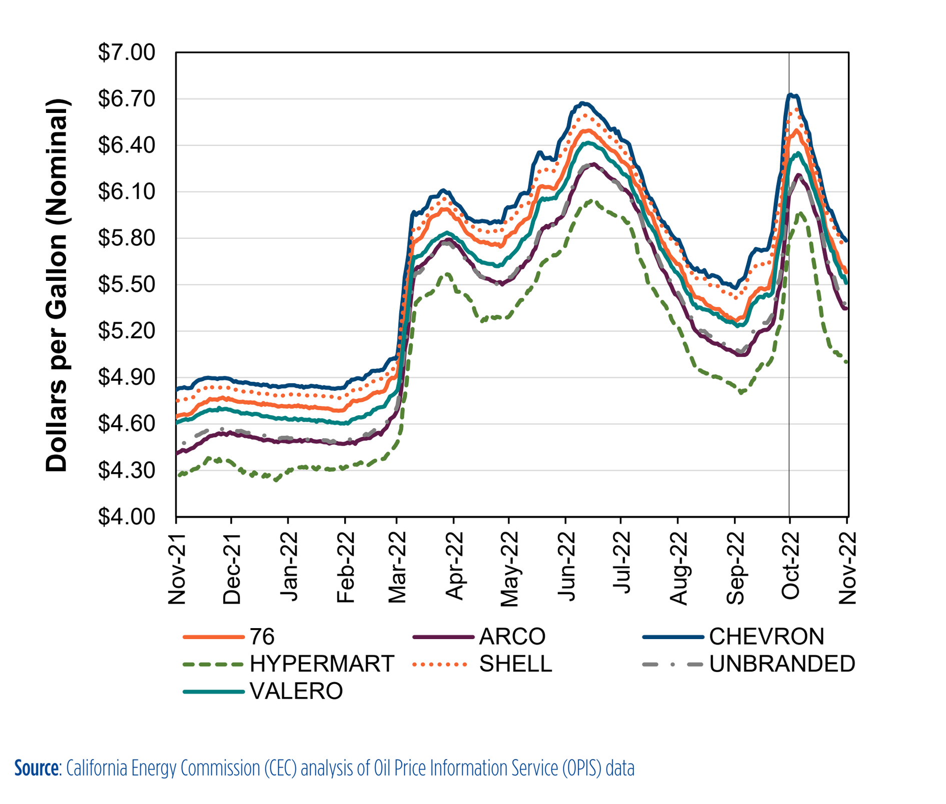
October 2022 vs. 2021

(Percentage Change)

76	33% higher
ARCO	36% higher
Chevron	33% higher
Hypermart	32% higher
Shell	33% higher
Unbranded	35% higher
Valero	34% higher

October 2022 Averages

76	$6.07
ARCO	$5.83
Chevron	$6.25
Hypermart	$5.47
Shell	$6.19
Unbranded	$5.85
Valero	$5.99



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

CALIFORNIA DIESEL RETAIL PRICES BY REGION

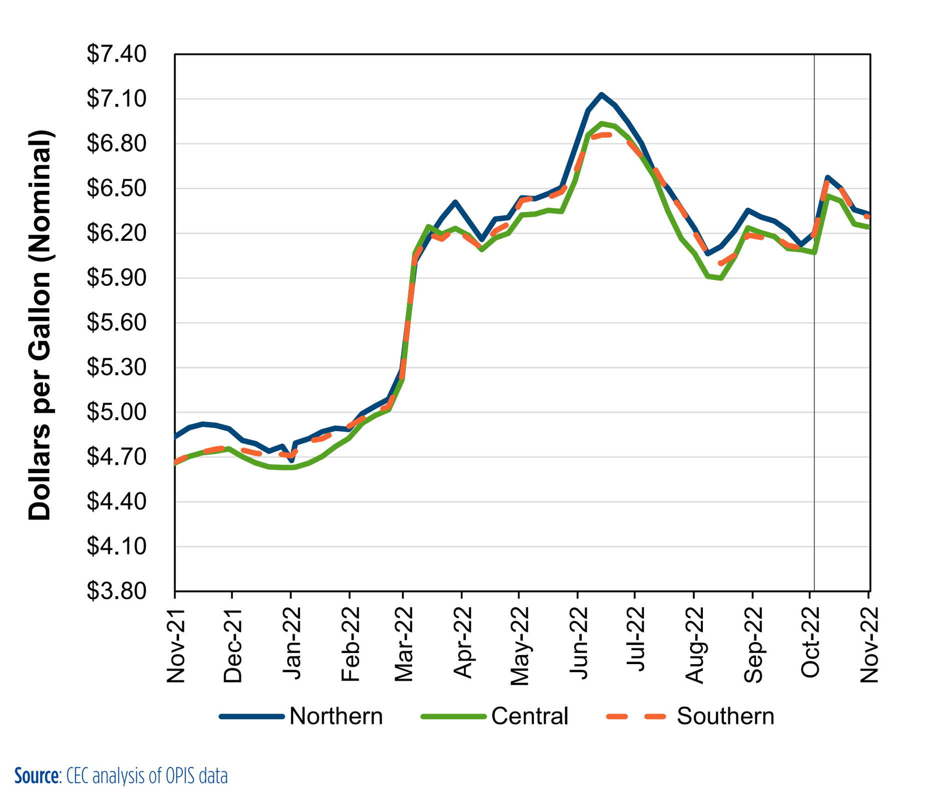
October 2022 vs. 2021

(Percentage Change)

Northern CA	36% higher
Central CA	39% higher
Southern CA	41% higher

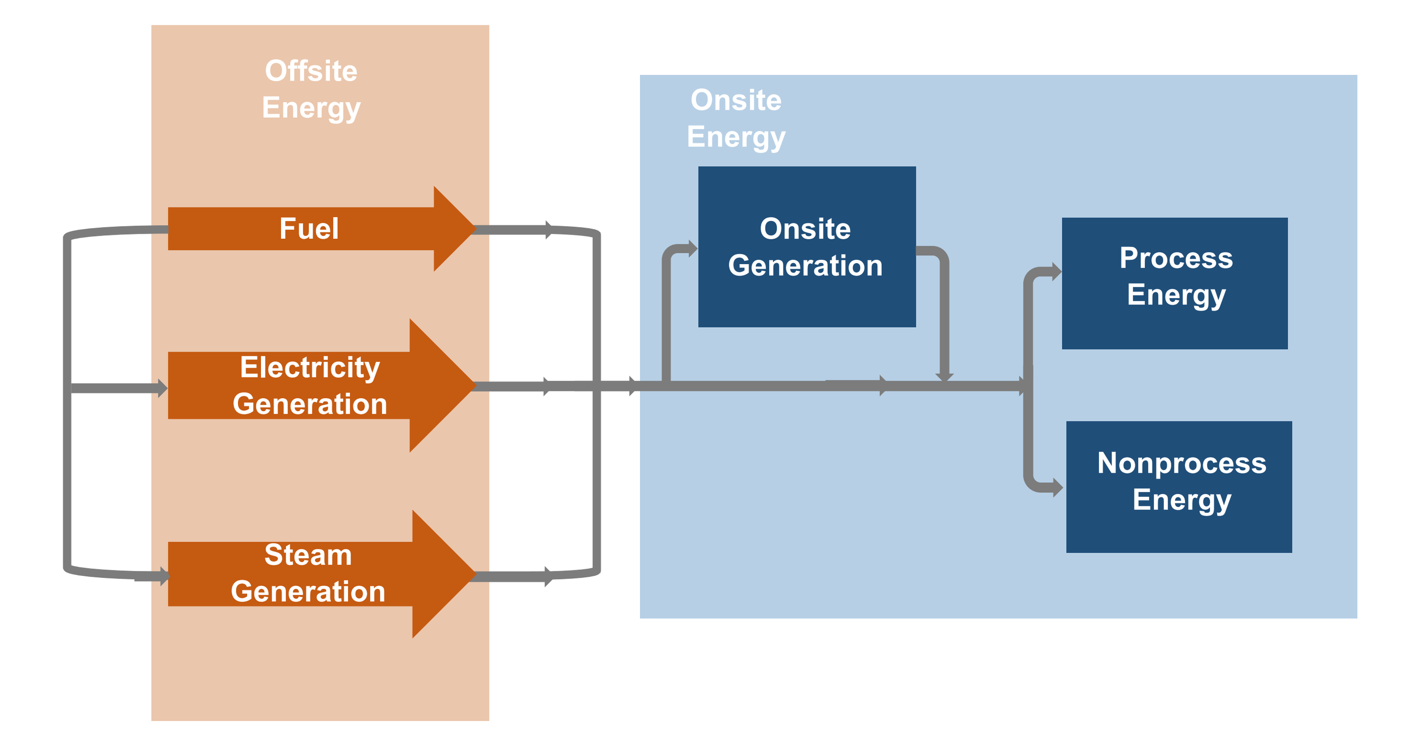
October 2022 Averages

Northern CA	$6.39
Central CA	$6.29
Southern CA	$6.39



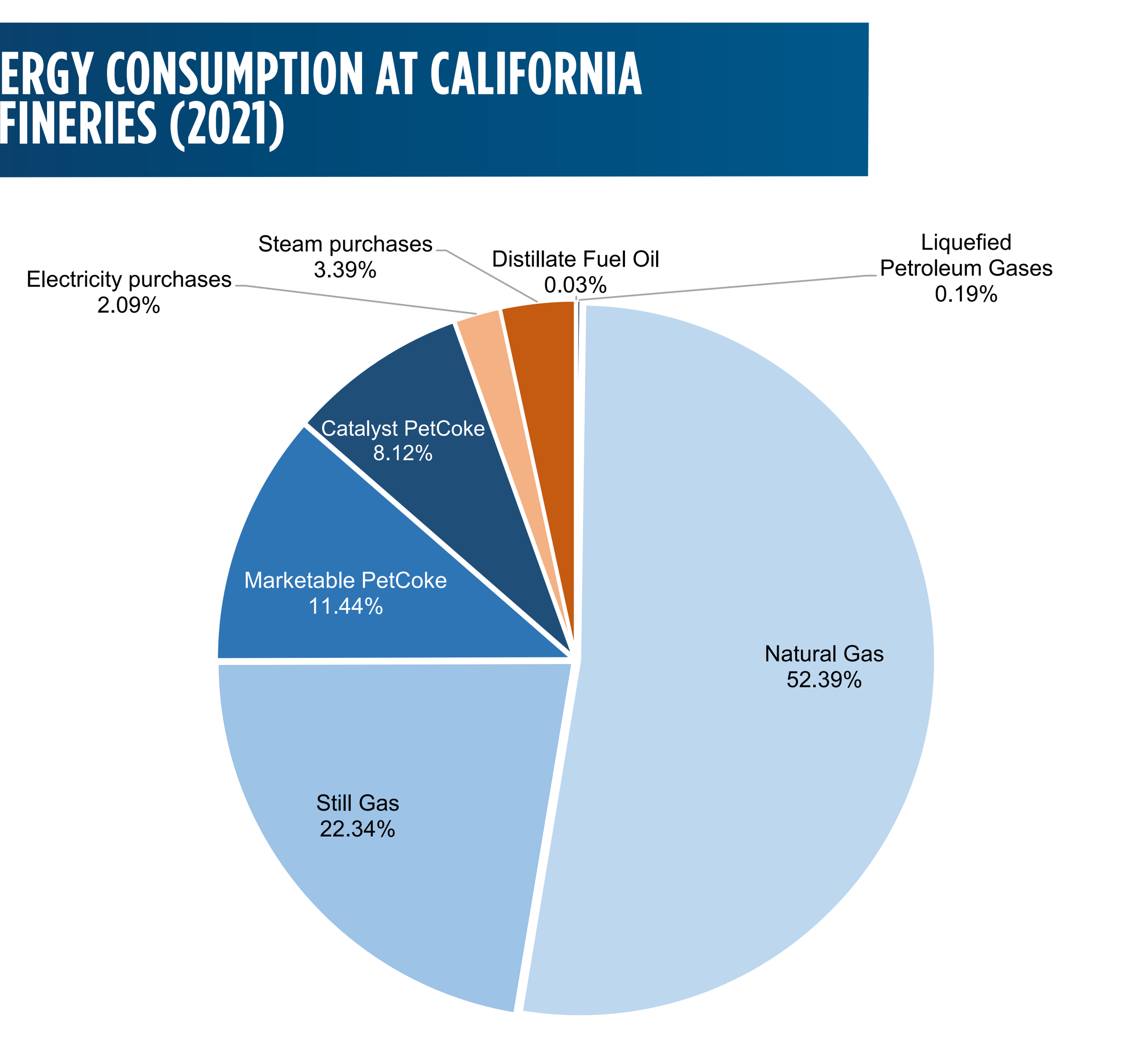
Source: CEC analysis of OPIS data

ENERGY FLOW AT REFINERIES



Source: U.S. Department of Energy - U.S. Manufacturing Energy Use and Greenhouse Gas Emissions Analysis

ENERGY CONSUMPTION AT CALIFORNIA REFINERIES (2021)



Source: CEC analysis of CEC M13 data
Notes: CEC M13 data for all refineries with fuel types converted to MMBtu

NATURAL GAS END USE AT REFINERIES

Natural Gas End Use	2014 Percent Share	2015 Percent Share
Cogeneration	45.9%	45.2%
Hydrogen Production	34.6%	34.0%
Heaters	17.7%	16.8%
Boilers	1.8%	3.9%

Source: CEC analysis of CEC survey data

FEATURED TOPIC

ENERGY USE AT REFINERIES: A LOOK AT NATURAL GAS

The petroleum refining sector has the greatest demand for process heating energy of all manufacturing sectors, according to the Department of Energy (DOE). This is because refining crude oil into marketable products, like gasoline, diesel, and jet fuel, requires an abundance of heat and steam energy. Natural gas plays a large role in meeting those energy demands and has meaningful weight over refinery operating costs.

ENERGY FLOW AT REFINERIES

Energy use at refineries can be grouped into two categories: *offsite energy use* and *onsite energy use*. Energy Flow at Refineries depicts the offsite and onsite energy flows at refineries. The primary offsite energy sources are, in descending order, direct fuel use, steam generation, and electricity generation, with the majority being direct fuel use (DOE). Direct fuel use is any process that is not steam or electricity generation. Sources of fuel include natural gas, fuel oils, byproduct fuels, and other petroleum-based fuels.

Onsite energy generation is used for *process energy* and *non-process energy*. Process energy involves the energy intensive processes required to refine crude oil such as distillation, cracking, reforming, and treating. Read the May 2020 Petroleum Watch for more on refinery operations. About 90 percent of onsite energy is used for processing, and the remainder is used for non-process energy. Non-process energy is used for facility support such as heating, ventilation, and air conditioning, lighting, and onsite transportation.

ENERGY SOURCES AT CALIFORNIA REFINERIES

Energy consumption data at California refineries is collected through the California Refinery Monthly Fuel Use Report and is required by all refineries to report to the CEC. Refinery reporting requirements include monthly fuel use by fuel type, electricity purchases, and steam purchases.

Energy Consumption at California Refineries (2021) shows a pie chart of energy consumption for California refineries in 2021. Consistent with the energy flow chart, offsite energy is shown in orange shades and onsite energy is shown in blue shades. To compare the energy content of fuels, all values were converted to British thermal units (Btu). A Btu is a measure of the heat content of fuels or energy sources. One Btu is approximately equal to the energy released by burning a match (EIA). Heat content is useful for comparing fuels on an equal basis.

In 2021, about 95 percent of energy use at California refineries was generated onsite, leaving just over 5 percent of energy generated offsite in the form of steam and electricity purchases. Of the onsite energy consumed, natural gas is the largest share at 52.4 percent, or 222.4 trillion Btu. This is followed by still gas at 22.3 percent, marketable petroleum coke at 11.4 percent, catalyst petroleum coke at 8.1 percent, liquified petroleum gases at 0.2 percent, and distillate fuel oil at 0.03 percent. Of the offsite energy consumed, steam purchases comprised 3.4 percent and electricity purchases comprised 2.1 percent of total energy consumption.

It is important to note that this analysis does not include natural gas consumed onsite for combined heat and power, also known as cogeneration. Cogeneration is when combustion turbine generators and steam turbine generators produce electricity and thermal energy for useful purposes. Cogeneration produces most of the electricity consumed at refineries, but refineries still purchase small amounts of electricity from California's electric grid, find more information on this topic in the January 2021 Petroleum Watch.

NATURAL GAS USE AT CALIFORNIA REFINERIES

Natural gas use at refineries is categorized into four applications: cogeneration, hydrogen production, heater, and boiler. Natural Gas End Use at Refineries lists the end-use shares of natural gas at California refineries using data from 2014 and 2015, collected through an ad hoc survey conducted in 2016. This data is not collected regularly; however, refinery fuel use does not vary significantly due to infrastructure architecture limitations. While energy flows may vary a little from year to year, they will stay within a small range as they are determined by the refineries' physical infrastructure. That hasn't changed since then, so these figures should still be accurate. Therefore, it is assumed that these ratios can still be applied to present day fuel use consumption at refineries.

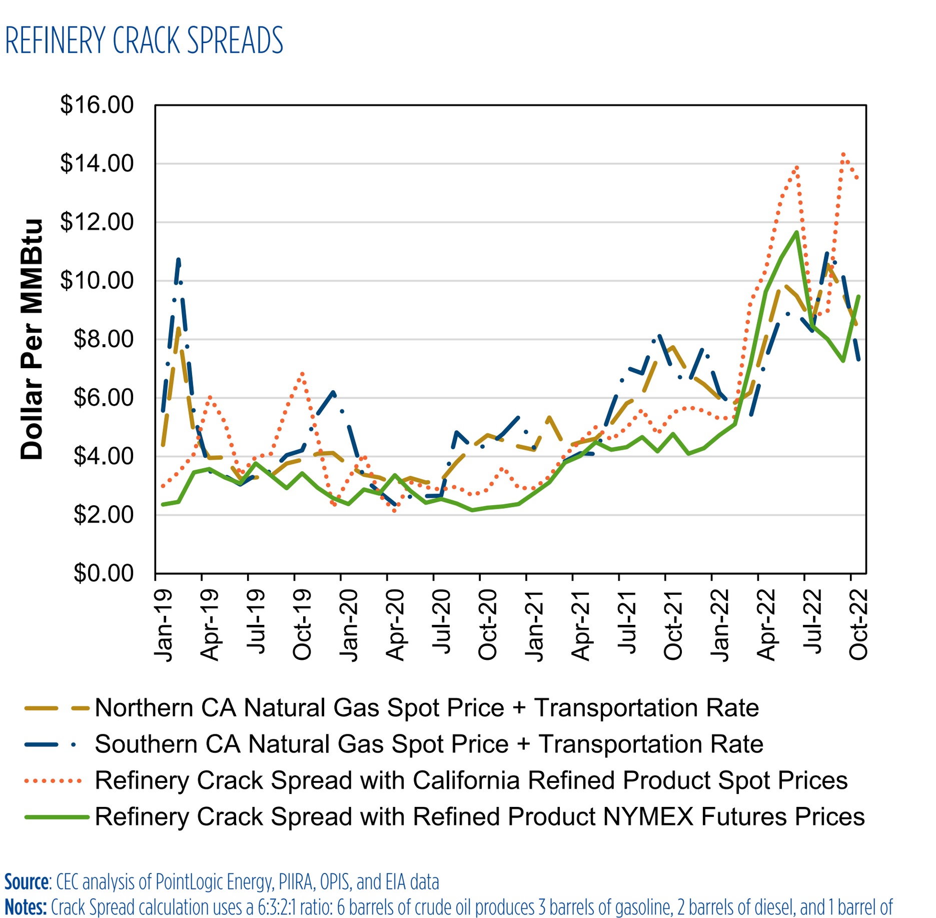
Cogeneration makes up just under half of natural gas use, around 45 percent. Hydrogen production from natural gas makes up about 35 percent. Hydrogen is produced from natural gas through a process called steam-methane reforming, the hydrogen is then used to lower the sulfur content of diesel fuel to make it compliant with air quality standards (EIA). The remaining share, approximately 20 percent, is used by heaters and boilers. Heaters and boilers are used in process heating systems to break down crude oil. Most process heaters and boilers are fueled by a combination of natural gas and fuel gas (hydrogen, methane, and other light-end gases produced in the refining of crude oil, read more in April 2021 Petroleum Watch).

HOW DOES NATURAL GAS AFFECT REFINERY OPERATING COSTS AND MARGINS?

Worldwide natural gas prices increased significantly in the second quarter of 2022. This largely has to do with the invasion of Ukraine by Russia on February 24, 2022, which had wide repercussions for global commodities, including natural gas. For the period between July 2021 to June 2022, the monthly average Henry Hub natural gas spot price, the U.S. benchmark, doubled from $3.84 per MMBtu to $7.70 per MMBTU in June 2022. The average inflation-adjusted monthly Henry Hub spot price reached a 12-month high of $8.17 per MMBtu in May 2022, the highest price since November 2008 (EIA). Since natural gas makes up more than half of fuel use for refineries, it brings into question natural gas prices' influence over refinery operating costs and margins.

To determine if natural gas costs influence California refinery margins, crack spreads can be used to estimate a refinery's margin per barrel of crude oil. Refinery Crack Spreads plots the California natural gas spot prices against two different refinery crack spread calculations in units of million Btu (MMBtu). The natural gas prices consist of monthly average spot prices for PG&E Citygate, representing Northern California, and SoCal Citygate, representing Southern California. There is a regional transportation rate added to the spot prices to account for transportation costs; however, these are price estimates and do not take into consideration the additional fees and tariffs associated with industrial natural gas use at refineries. To note, the gap in the Southern California natural gas prices trend line is due to the removal of an outlier that occurred in February 2021 when the average spot price for that month reached $29.85 per MMBtu (daily high of $146.42/MMBtu), which was due to a winter storm.

REFINERY CRACK SPREADS



Source: CEC analysis of PointLogic Energy, PIIRA, OPIS, and EIA data
Notes: Crack Spread calculation uses a 6:3:2:1 ratio: 6 barrels of crude oil produces 3 barrels of gasoline, 2 barrels of diesel, and 1 barrel of jet fuel. Text provides more information on the specific products and prices used.

Refinery crack spreads are the estimated refiner margins of refining a barrel of crude oil. Specifically, it is the difference between the price of crude oil refiners pay and the spot price of the petroleum products they sell. The 6:3:2:1 crack spread ratio represents six barrels of crude oil becomes three barrels of gasoline, two barrels of diesel, and one barrel of jet fuel. These formulas do not account for refining costs, other fees, and the production of other petroleum products and should be taken as an estimation of a refinery's margin per crude oil barrel. The formula to represent California refinery crack spreads uses product spot prices for products sold within Petroleum Administration Defense District 5 (PADD 5) and a California Crude Basket (weighted average of local San Joaquin Valley, Alaskan North Slope, and Brent International crude oil prices). More information on crack spreads can be found in the April 2021 Petroleum Watch.

The NYMEX futures crack spread is using the same ratio (6:3:2:1) but the prices are different. It still uses California Crude Basket, but it replaces the California Refined Product Prices with NYMEX future prices. This gives a comparison between California refineries and the others in the nation. The NYMEX future prices replace California Air Resources Board Oxygenated Blend (CARBOB) spot price, and the No. 2 Heating Oil (New York Harbor) price replaces the price for both California Air Resources Board (CARB) Diesel and Jet Fuel spot prices.

In Refinery Crack Spreads, the California Crack Spread and the NYMEX Futures Crack Spread somewhat follow the natural gas price trends, with natural gas being more expensive or equal to refined products on a Btu basis until February 2022. Beginning February 2022, natural gas prices and crack spreads increased, surpassing $8.00 per MMBtu by May 2022. In July 2022, refinery crack spreads and natural gas prices were relatively equal on a Btu basis, until September 2022 when natural gas prices started to decline to the $10.00 per MMBtu range. During that same month, the NYMEX Futures Crack Spread was at an average of $7.26 per MMBtu while the California Crack Spread increased to an average of $14.33 per MMBtu, almost double the NYMEX Futures Crack Spread. The California Crack Spread peak in September 2022 is an almost 60 percent increase from the August 2022 average of $8.97 per MMBtu. This volatility in the California Crack Spread is absent in the NYMEX Futures Crack Spread as well as the natural gas prices, suggests the driver behind the price movements during September 2022 in California were not related to natural gas prices and were isolated to California (as opposed to the nation).

CALIFORNIA'S PETROLEUM PRODUCTS MARKET

While this analysis does not find a conclusive correlation between natural gas prices and refinery margins, there are other factors that influence California's petroleum product supply that make the region more vulnerable to price swings. Not only does California lack the infrastructure to import products from the greater U.S., but the state also has stricter fuel specifications, both of which contribute to an isolated fuels market (more on California's infrastructure and fuel specifications). This means that most of the fuel supply is produced in state and any disruptions, like refinery outages, have a large effect. California refining capacity has decreased since the idling of Marathon Martinez refinery in August 2020, which resulted in a loss of 166,000 barrels per day or 9 percent of California's refining capacity (August 2020 Petroleum Watch). Additionally, the EIA reports that lower refinery runs in September 2022 contributed to withdrawals from West Coast product inventories, tightening supply. The combination of these factors plays a role in the volatility of California's petroleum products market.

The CEC welcomes feedback on Petroleum Watch.
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