Independent Statistics & Analysis
U.S. Energy Information Administration

Refinery Outages: First-Half 2016

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1. Preface

This report examines U.S. refinery outages planned for the first half of 2016 and the implications for available refinery production capacity, petroleum product markets, and the supply of gasoline, diesel fuel, and jet fuel. Dissemination of such analyses can be beneficial to market participants who may otherwise be unable to access such information.

Refinery outages result from the planned shutdown of refinery units for maintenance and upgrades, and from unplanned shutdowns from a variety of causes such as mechanical failure, bad weather, power failures, fire, and flooding. Planned maintenance is typically scheduled when refined petroleum product consumption is relatively low, in the fall and in the first quarter when there is less demand for transportation fuels.

This report analyzes the potential implications of planned shutdowns of various refinery units as reported by Industrial Info Resources (IIR) and uses individual refinery models from PRISM software developed by Baker & O'Brien, Inc. The specific refinery units analyzed are the atmospheric crude distillation unit (ACDU), the fluidized catalytic cracking unit (FCCU), the catalytic reforming unit (CRU), the hydrocracking unit (HU), and the coking unit (CU). Definitions of these units can be found in the EIA glossary. A more detailed discussion of the methodology, which is new with the current edition of this recurring report, can be found in Section 3.

This report focuses on how planned refinery outages may affect the adequacy of regional gasoline, diesel fuel, and jet fuel, as defined by Petroleum Administration for Defense District (PADD) areas. Therefore, this report does not include a discussion of national-level balances.

National supply/demand balances have very limited implications for the regional adequacy of petroleum product supply because pipeline infrastructure, geography, and marine shipping regulations constrain the amount of product that can flow among the different regions of the United States. In most regions of the country, most petroleum products are supplied by in-region refinery production.

Because unplanned outages are by definition unexpected and vary widely, estimates of future unplanned outages based on historical averages are inherently problematic. Because of this uncertainty, this report does not attempt to estimate future unplanned outages.

EIA plans to continue work to improve the analysis of the effect of refinery outages on the availability of supply, including the incorporation of information from sub-PADD studies recently completed for PADDs 1, 3, and 5 and planned studies of PADDs 2 and 4.

2. Executive Summary

Planned refinery maintenance during the first half of 2016 is not expected to adversely affect the supply of gasoline, jet fuel, and distillate fuel. The effect of refinery outages on product supplies depends on many factors, including petroleum product demand, the availability of product supplies from available refinery capacity, inventories, imports and redirected exports, as well as actual levels of both planned and unplanned refinery outages. Barring unusually high unplanned outages, planned outages that extend beyond the planned period, or higher-than-expected demand, the supply of gasoline, jet fuel, and distillate fuel should be adequate in all regions during the first half of 2016.

As in previous issues, this edition of the report considers the supply of petroleum products on regional (both PADD and sub-PADD) levels, rather than at a national level. National balances have very limited meaning for the adequacy of supply because pipeline infrastructure, geography, and marine shipping regulations constrain the amount of product that can flow among the different regions of the United States.

PADD 1 planned maintenance is very light for atmospheric crude distillate, fluidized catalytic cracking, and reforming capacity in the first half of 2016. The planned outages will result in estimated production loss in gasoline of 31,000 b/d and 27,000 b/d in March and April, respectively, and production loss in distillate fuel of 12,000 b/d and 14,000 b/d in March and April, respectively. Production losses in other months during the first half of 2016 are negligible. The total estimated production loss induced by the expected outages accounts for only 2.9% of existing gasoline inventory, 1.0% of jet fuel inventory, and 1.2% of distillate inventory. The production loss in PADD 1 could be covered by existing product inventory.

Planned maintenance in PADD 2 is concentrated from March to May, with outage rates of crude distillation and reforming capacities close to the 10-year maximum level. The high planned outages of reforming capacity could cause tightness for octane. Outage rates of hydrocracking capacity will be higher than the 10-year maximum in May and June. Planned maintenance of fluidized catalyst cracking capacity will be above the 10-year maximum in February, a low-gasoline-demand month, and remain near the 10-year average between March and June. The outages will result in moderate production loss of petroleum products from February to June. The highest losses occurred in February, consisting of 132,000 b/d in gasoline, 53,000 b/d in jet fuel, and 60,000 b/d in distillate fuel. The total estimated production losses in gasoline, jet fuel, and distillate fuel account for 29%, 94%, and 25% of existing inventories as of January 8, which indicate that current inventories must be supplemented by supplies from other regions, such as the Gulf Coast, to offset lost production from the planned outages.

Planned maintenance in PADD 3 of reforming, hydrocracking, and coking units is intermittently above or close to the 10-year maximum, while planned maintenance for other units is near or below the 10-year average. The outages will result in moderate production loss in petroleum products. From February to April, the expected average losses are 303,000 b/d in gasoline, 28,000 b/d in jet fuel, and 113,000 b/d in distillate fuel. Gulf Coast inventories are all near or above the 10-year maximum at the beginning of 2016. The total estimated production loss as a result of the planned outages accounts for 33% of existing gasoline inventory, 18% of existing jet fuel inventory, and 21% of existing distillate inventory. As a result, there may be a need to divert exports from the U.S. Gulf Coast to domestic markets to offset lost production from the planned outages.

Planned outages in PADD 4 are moderate and concentrated in the period from February to April. Total estimated production losses from planned outages account for 34% of gasoline inventory, 71% of jet fuel inventory, and 35% of distillate inventory. The inventory levels for those products were all close to the 10-year maximum as of late January, however, continued supply from other regions will be required to offset lost production from the planned outages.

In PADD 5, planned outages between February and June will be higher than the 10-year average in coking capacities, and generally near or below the 10-year average in crude distillation, fluidized catalytic cracking, reforming, and hydrocracking capacities. Because a large share of FCC capacity remains offline from February to June from a previous unplanned outage, the total estimated production loss is concentrated in gasoline. From February through June, average production loss of gasoline is 131,000 b/d, and the average losses in jet fuel and distillate fuel are 27,000 b/d and 20,000 b/d, respectively. The total estimated reduction of petroleum products induced by the outages accounts for 66% of the existing gasoline inventory, 47% of jet fuel inventory, and 20% of distillate fuel inventory. Therefore, continued imports of gasoline and jet fuel into the West Coast will be required to provide adequate supplies.

3. Methodology: Refinery Modeling and Base Cases

Beginning with this report, EIA is using a new methodology to examine potential production implications of refinery unit outages. EIA subscribes to PRISM software, developed by Baker and O'Brien Inc., and uses this tool to simulate the shutdown of various refinery units.

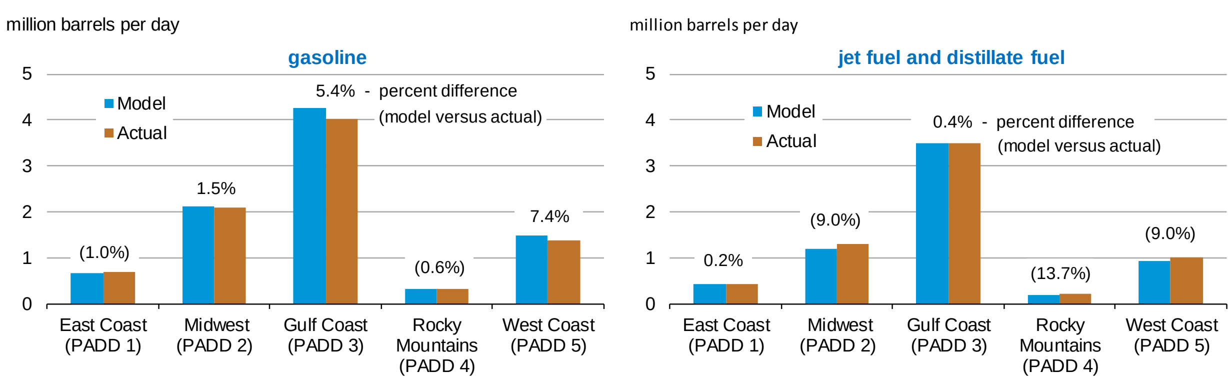
PRISM includes detailed computer models of 118 of the 137 operating U.S. refineries reported by EIA. Each refinery model contains individual refinery unit simulations that can be manipulated to change unit operations, including a complete shutdown of the unit. The remaining refinery units can be operated through operational changes, use of inventoried or purchased feedstocks, and by changes in refinery crude slates. The resulting petroleum product output with unit(s) down for planned maintenance can then simulated. To assess production losses resulting from planned maintenance, however, these results must be compared with a more normal mode of refinery operations, thereby requiring the simulation of refinery base cases.

A base case for each refinery in the PRISM database was developed to represent high-utilization operations using nonconfidential data with the following assumptions:

- Input actual crude imports – EIA's Company Level Import data identifies source country, API gravity level, and sulfur level, and are matched to crudes in the PRISM database
- Assume 90% utilization on key units – crude distillation units, fluidized catalytic crackers, hydrocrackers, cokers, and reformers
- Input domestic crude slates per utilization assumption and local availability
- Buy intermediate feedstocks as necessary to fill conversion units
- Limit production of unfinished products

The results of these base case simulations were combined at the PADD level and compared with actual production levels reported by EIA in 2014, a year of very high refinery utilizations. For gasoline and middle distillate (including jet fuel, diesel, and heating oil) production, the model results are close to the 2014 actuals and can therefore provide a reasonable approximation of refinery production capability.

Figure 1. U.S. refinery production base-case results vs. 2014 actual



Source: U.S. Energy Information Administration

EIA plans to continue work to improve refinery modeling, particularly the base case analyses, by incorporating the results of sub-PADD studies recently completed for PADDs 1, 3, and 5 and a planned study of PADDs 2 and 4. EIA will also perform post-outage comparisons between EIA projected production changes and actual results and determine further potential improvements.

4. Recent Market Conditions

As of February 26, the price of North Sea Brent crude oil averaged $36 per barrel (b). In the March *Short-Term Energy Outlook* (STEO), EIA forecasts that Brent will average $34/b for all of 2016, $18/b lower than the 2015 average. The lower price reflects the continued global oversupply of crude oil and has been characterized by elevated volatility.

Global crude oil supplies have risen sharply over the past few years, primarily because of rapid and sustained growth in production in North America and, more recently, from the Organization of the Petroleum Exporting Countries. Although lower crude prices have led to recent monthly declines in U.S. oil production, the March STEO estimated that U.S. crude production for 2016 will average 8.7 million barrels per day (b/d), which is 3.7 million b/d above 2008 levels. U.S. crude oil production is forecast to decrease through third-quarter 2017 and to average 8.2 million b/d in 2017.

Although global oil supply growth has been strong, economic growth outside of the United States has been slow, particularly in Russia and non-Organization for Economic Cooperation and Development (OECD) Asia, the largest source of global petroleum demand growth since 2009. Economic growth in the United States has been relatively strong. EIA estimates global consumption of petroleum and other liquids grew by 1.33 million b/d in 2015, averaging 93.7 million b/d for the year. EIA expects global consumption of petroleum and other liquids to grow by 1.2 million b/d in both 2016 and 2017.

With continued access to price-advantaged crude oil and natural gas, sophisticated upgrading equipment, and a strategic location compared with demand centers in Latin America, U.S. refineries have been running at record-high levels. Through December 2015, gross inputs averaged 16.4 million b/d, the highest annual average since EIA began collecting data in 1985. Gross inputs to U.S. refineries exceeded 17 million b/d for six consecutive weeks in July and August, a level not previously reached or exceeded in any week since EIA began publishing the data in 1990. Refinery production of gasoline and distillate has increased to supply growing demand in global markets, contributing to a widening U.S. petroleum product trade surplus. Monthly domestic demand for gasoline has averaged 3% higher than last year, and gasoline crack spreads exceeded those for distillate for much of last summer. For the week ending February 19, gross U.S. refinery inputs were 15.9 million b/d, more than 700,000 b/d higher than the five-year average.

Record-high U.S. refinery runs in 2015 contributed to high U.S. gasoline, distillate (diesel fuel and heating oil), and jet fuel inventories. Gasoline inventories in all regions of the nation were above their respective five-year averages for the week ending February 19, 2016. PADD 2 gasoline inventories were just under 60 million barrels, 5.7 million barrels higher than the five-year average, the highest difference of any PADD, and outside of the five-year range. Gasoline inventories in PADD 5 were 33 million barrels, or only 1.3 million barrels above the five-year range. Distillate inventories in all regions of the country were also at or above their five-year averages for the same week. PADD 4 distillate inventories were 3.6 million barrels, only 93 thousand barrels below the five-year average. PADD 1 distillate inventories were 60 million barrels or 19.3 million barrels higher than the five-year average and outside of the five-year range. Inventories of kerosene-type jet fuel are within or above the five-year ranges for all regions of the nation, and up slightly versus last year.

Falling crude oil prices, coupled with increased refinery production of gasoline and distillate (diesel fuel and heating oil), have led to declines in gasoline and distillate prices. After averaging $2.43 per gallon (gal) in 2015, the U.S. average retail price for regular gasoline is forecast to average $1.89/gal in 2016, which would be the first annual average below $2.00/gal since 2004. The U.S. average retail price for ultra-low sulfur diesel (ULSD) is expected to average $2.12/gal in 2016, the lowest annual average since 2004.

EIA estimates that U.S. gasoline consumption increased by 240,000 b/d (2.7%) in 2015. At 9.2 million b/d, U.S. gasoline consumption in 2015 was the highest level since the peak of 9.3 million b/d in 2007. Although total nonfarm employment and total vehicle-miles traveled have increased by 2.9% and 3.7%, respectively, since 2007, improving vehicle fuel economy has steadily contributed to lower gasoline consumption. Gasoline consumption is forecast to increase by 1% in 2016, as the effect of continued economic growth on highway travel offsets a long-term trend toward vehicles that are more fuel efficient. U.S. consumption of distillate fuel is estimated to have fallen by 60,000 b/d (1.5%) in 2015. Distillate consumption is expected to fall by 50,000 b/d (1.1%) and rise by 110,000 b/d (2.9%) in 2016 and 2017, respectively. The future growth is driven by increasing manufacturing output, foreign trade, and marine fuel use.

U.S. participation in the global petroleum products markets has increased steadily in the past several years. Total U.S. product exports averaged 4.3 million b/d in 2015, up 2.3 million b/d from 2009. Exports generally act as a stabilizer in U.S. product markets, similar to inventories, as this supply can be diverted to domestic markets if product balances tighten, depending on the structure of sales contracts. Supplying overseas markets with product from economically-efficient U.S. refineries also helps balance global product supply and demand, which in turn helps U.S. regions that rely on imports. In 2015, the U.S. East Coast imported an average of 0.9 million b/d of gasoline and distillate.

5. East Coast (PADD 1) Regional Outage Review

The East Coast region, which includes all states in New England, the Central Atlantic, and the Lower Atlantic, has 1.3 million barrels per stream day[1] (b/sd) of atmospheric crude distillation capacity, 0.5 million b/sd of fluidized catalytic cracking capacity, 0.3 million b/sd of catalytic reforming capacity, 46,000 b/sd of hydrocracking capacity, and 76,000 b/sd of coking capacity.

As the East Coast is structurally short of refinery capacity—meaning that regional demand is higher than regional production—the region relies on transfers of petroleum products from other regions, primarily from the Gulf Coast, and on imports from the actively-traded Atlantic Basin market. As a result, refinery outages in other parts of the country and in the countries from which gasoline and distillate are imported can affect East Coast supply. Planned maintenance at refineries on the Gulf Coast is not expected to adversely affect supply of gasoline and distillate to the East Coast, as the substantial volumes of gasoline and distillate typically exported from the Gulf Coast can be diverted to domestic markets if product balances tighten.

Planned refinery maintenance in PADD 1 is generally expected to be very light in the first half of 2016.

Table 1. East Coast (PADD 1) planned refinery capacity outages

Atmospheric crude distillation

	thousand barrels per day			as percentage of capacity		
Month	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**
January	15	3	16	1%	0%	1%
February	1	98	60	0%	8%	5%
March	0	0	69	0%	0%	5%
April	15	0	53	1%	0%	4%
May	2	0	47	0%	0%	4%
June	0	0	21	0%	0%	2%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

[1] Stream day capacity is the maximum number of barrels of input that a distillation facility can process within a 24-hour period when running at full capacity under optimal crude and product slate conditions with no allowance for downtime. Barrels per calendar day is a measure of the amount of input that a distillation unit can process in a 24-hour period under usual operating conditions. It takes into account both planned and unplanned maintenance. Stream day capacity is typically about 6% higher than calendar day capacity.

Fluidized catalytic cracking

Month	2016 planned outages (thousand barrels per day)	2015 planned outages (thousand barrels per day)	2006-15 average planned outages (thousand barrels per day)	2016 planned outages (as percentage of capacity)	2015 planned outages (as percentage of capacity)	2006-15 average planned outages (as percentage of capacity)
January	0	0	14	0%	0%	3%
February	0	70	36	0%	15%	7%
March	0	8	62	0%	2%	13%
April	0	3	29	0%	1%	6%
May	0	0	18	0%	0%	4%
June	0	0	0	0%	0%	0%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Reforming

Month	2016 planned outages (thousand barrels per day)	2015 planned outages (thousand barrels per day)	2006-15 average planned outages (thousand barrels per day)	2016 planned outages (as percentage of capacity)	2015 planned outages (as percentage of capacity)	2006-15 average planned outages (as percentage of capacity)
January	0	0	3	0%	0%	1%
February	0	14	16	0%	5%	6%
March	14	48	19	6%	19%	8%
April	8	13	14	3%	5%	6%
May	1	0	14	0%	0%	5%
June	0	0	12	0%	0%	5%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Hydrocracking

Month	2016 planned outages (thousand barrels per day)	2015 planned outages (thousand barrels per day)	2006-15 average planned outages (thousand barrels per day)	2016 planned outages (as percentage of capacity)	2015 planned outages (as percentage of capacity)	2006-15 average planned outages (as percentage of capacity)
January	0	0	4	0%	0%	8%
February	0	0	1	0%	0%	1%
March	8	0	0	18%	0%	1%
April	10	0	3	21%	0%	7%
May	0	0	6	0%	0%	13%
June	0	0	1	0%	0%	3%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

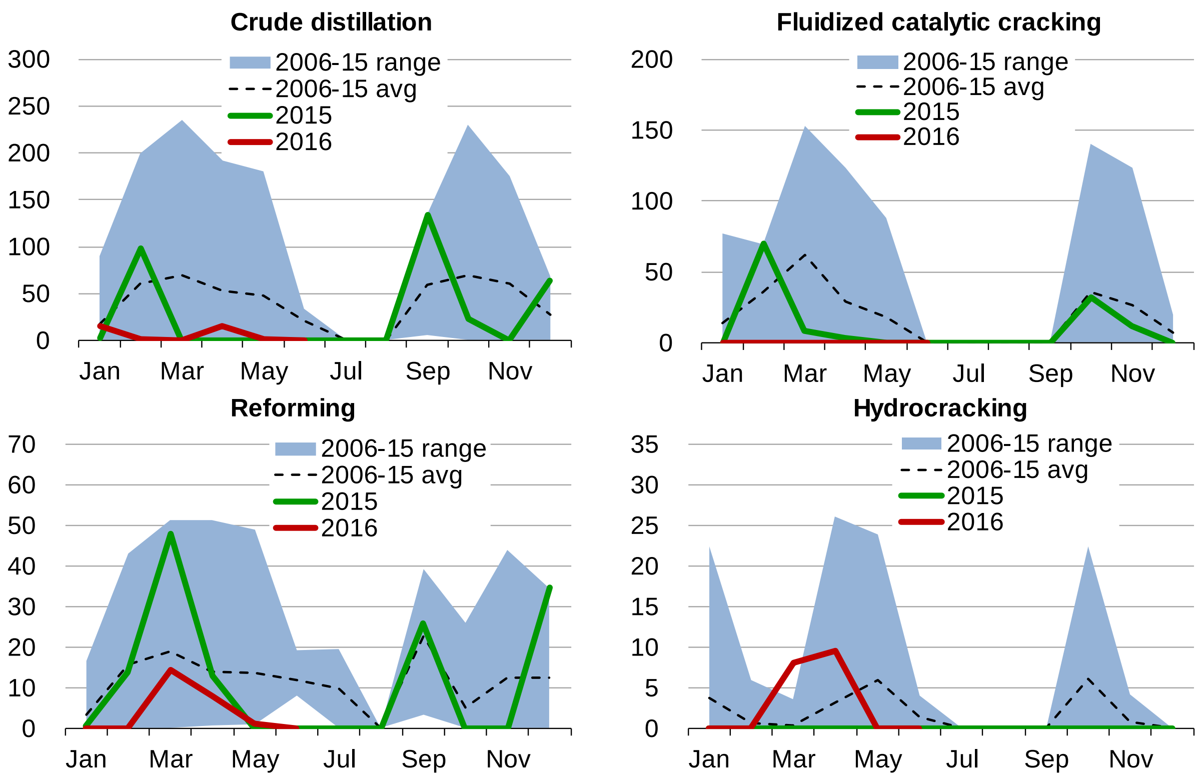
Coking

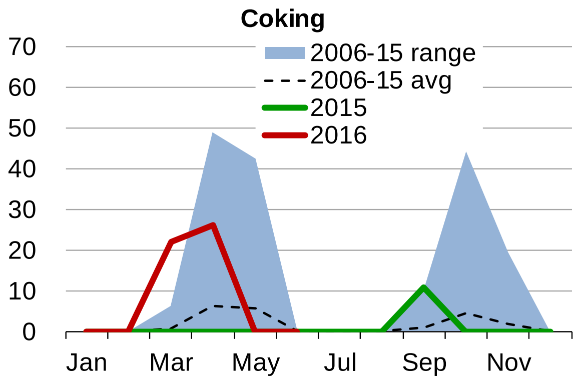
Month	thousand barrels per day			as percentage of capacity		
	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	0	0	0	0%	0%	0%
February	0	0	0	0%	0%	0%
March	22	0	1	29%	0%	1%
April	26	0	6	34%	0%	8%
May	0	0	6	0%	0%	8%
June	0	0	0	0%	0%	0%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Figure 2. East Coast (PADD 1) planned refinery capacity outages

thousand barrels per day



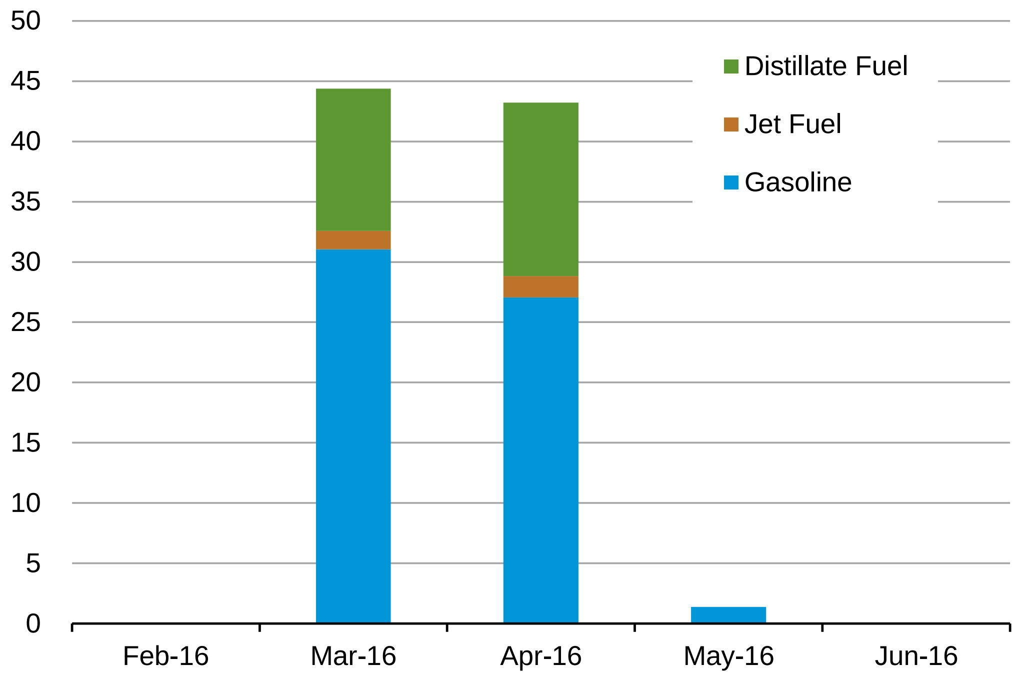


Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

PADD 1 planned maintenance is expected to be very light for atmospheric crude distillation, fluidized catalytic cracking, and reforming capacity in the first-half of 2016. The planned outages will result in estimated production loss in gasoline of 31,000 b/d and of 27,000 b/d in March and April, respectively, and production loss in distillate fuel of 12,000 b/d and of 14,000 b/d in March and April, respectively (Figure 3). Production losses in other months during the first half of 2016 are negligible.

Figure 3. East Coast (PADD 1) production losses as a result of planned outages

thousand barrels per day

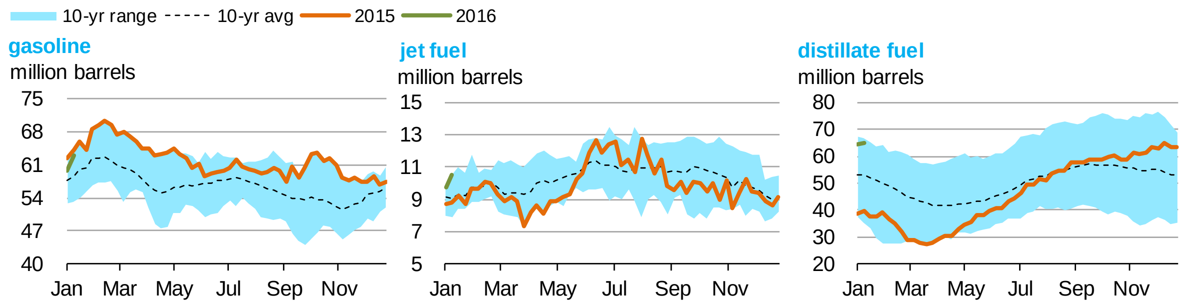


Source: U.S. Energy Information Administration, based IIR data as of January 4, 2016

According to EIA's PADD-to-PADD movement of petroleum products, in the first 10 months of 2015, the East Coast received, on average, 1.6 million b/d of gasoline blending components and 884,000 b/d of distillate fuel from the Gulf Coast. The production loss shown in Figure 3 is relatively very light.

The total estimated production loss resulting from the expected outages accounts for only 2.9% of existing gasoline inventory, 1.0% of jet fuel inventory, and 1.2% of distillate inventory. Therefore the production loss in PADD 1 could be covered by existing product inventory or increased imports.

Figure 4. East Coast (PADD 1) petroleum product inventories, 2015-present



Sources: U.S. Energy Information Administration

6. Midwest (PADD 2) Regional Outage Review

PADD 2 includes North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Kentucky, and Tennessee. The region has 26 operating refineries with a combined atmospheric crude distillation capacity of 4.0 million barrels per stream day[2] (b/sd), fluidized catalytic cracking capacity of 1.3 million b/sd, catalytic reforming capacity of 0.85 million b/sd, hydrocracking capacity of 0.28 million b/sd, and coking capacity of 0.58 million b/sd.

In 2015, refineries in the Midwest had high levels of runs when not disrupted by unplanned outages. For the first nine months of 2015, refinery runs were at or above the five-year average. However, late in the year, outages caused runs to drop to five-year lows.

Planned refinery maintenance in the first half of 2016 in PADD 2 is higher than in 2015 and the 10-year historical average (Figure 5).

Table 2. Midwest (PADD 2) planned refinery capacity outages

Atmospheric crude distillation

	thousand barrels per day			as percentage of capacity		
Month	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**
January	88	0	44	2%	0%	1%
February	51	25	83	1%	1%	2%
March	419	52	236	10%	1%	6%
April	551	0	216	14%	0%	5%
May	375	8	154	9%	0%	4%
June	170	78	109	4%	2%	3%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

[2] Stream day capacity is the maximum number of barrels of input that a distillation facility can process within a 24-hour period when running at full capacity under optimal crude and product slate conditions with no allowance for downtime. Barrels per calendar day is a measure of the amount of input that a distillation unit can process in a 24-hour period under usual operating conditions. It takes into account both planned and unplanned maintenance. Stream day capacity is typically about 6% higher than calendar day capacity.

Fluidized catalytic cracking

	thousand barrels per day			as percentage of capacity		
Month	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	2	0	1	0%	0%	0%
February	115	0	12	9%	0%	1%
March	39	0	50	3%	0%	4%
April	40	69	64	3%	5%	5%
May	49	9	54	4%	1%	4%
June	55	58	22	4%	5%	2%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Reforming

	thousand barrels per day			as percentage of capacity		
Month	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	2	0	7	0%	0%	1%
February	22	0	15	3%	0%	2%
March	58	0	52	7%	0%	6%
April	110	0	56	13%	0%	7%
May	105	0	33	12%	0%	4%
June	83	7	13	10%	1%	2%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Hydrocracking

	thousand barrels per day			as percentage of capacity		
Month	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	0	0	1	0%	0%	0%
February	0	0	2	0%	0%	1%
March	32	0	20	11%	0%	7%
April	4	0	17	2%	0%	6%
May	26	0	4	9%	0%	1%
June	35	0	0	12%	0%	0%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

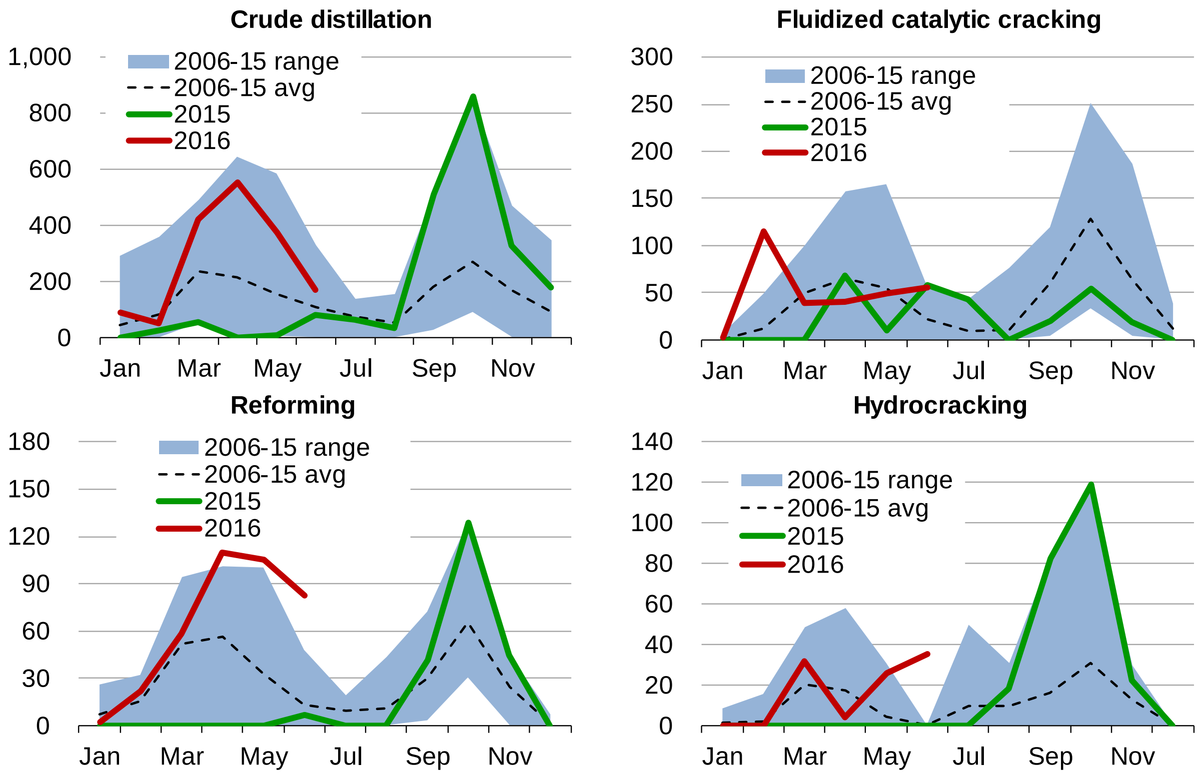
Coking

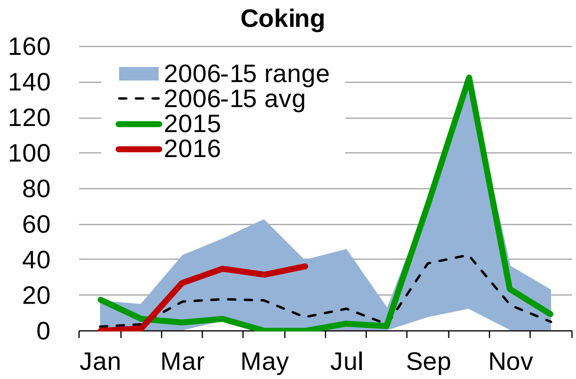
	thousand barrels per day			as percentage of capacity		
Month	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**
January	0	17	2	0%	3%	0%
February	1	7	4	0%	1%	1%
March	26	5	16	5%	1%	3%
April	35	7	18	6%	1%	3%
May	32	0	17	5%	0%	3%
June	37	0	7	6%	0%	1%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Figure 5. Midwest (PADD 2) planned refinery capacity outages

thousand barrels per day



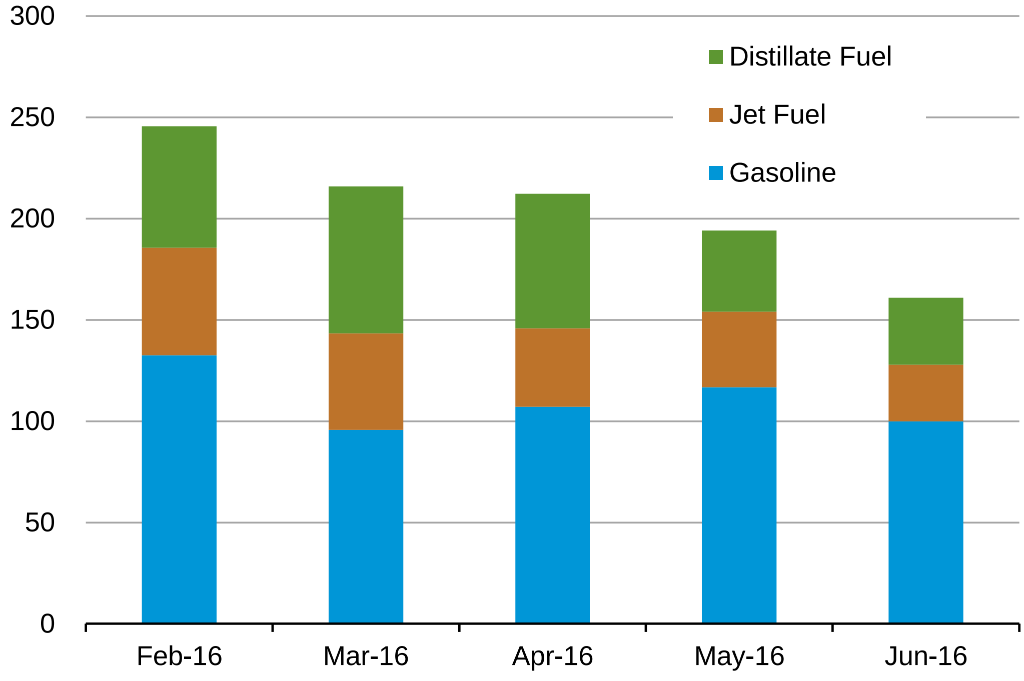


Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Planned Midwest maintenance is concentrated in March and April, with outage rates of crude distillation and reforming capacities close to the 10-year maximum. The high level of planned outages of reforming capacity could cause tightness for octane. Outage rates of hydrocracking capacity will be higher than the 10-year maximum in May and June. Planned maintenance of fluidized catalyst cracking capacity will be above the 10-year maximum in February, a low-gasoline-demand month, and remain near the 10-year average between March and June.

Figure 6. Midwest (PADD 2) production losses as a result of planned outages

thousand barrels per day

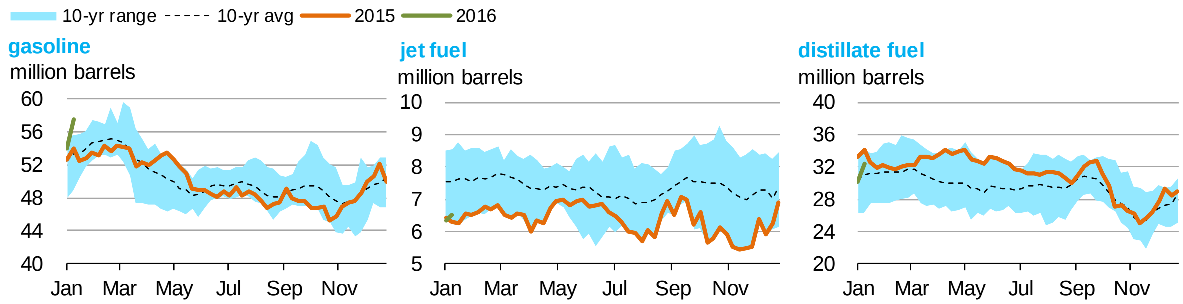


Source: U.S. Energy Information Administration, based IIR data as of January 4, 2016

The outages will result in moderate production loss of petroleum products from February to June. The highest losses will occur in February, with 132,000 b/d of gasoline, 53,000 b/d of jet fuel, and 60,000 b/d of distillate fuel (Figure 6).

The total estimated production losses in gasoline, jet fuel, and distillate fuel account for 29%, 94%, and 25% of existing inventories as of January 8, which indicate that additional supply from other regions may be needed to make up for lost in-region production.

Figure 7. Midwest (PADD 2) petroleum product inventories, 2015-present



Sources: U.S. Energy Information Administration

The Midwest receives gasoline, distillate, and jet fuel from the Gulf Coast. However, the time required for resupply to reach the Midwest from the Gulf Coast varies considerably across the region because of its size. Resupply can reach Oklahoma, Kansas, and Missouri from the Gulf Coast within 7-10 days, but it may take close to 30 days to reach the northernmost states at the end of the supply line. As a result, unplanned outages in the northernmost states could lead to supply disruptions.

7. Gulf Coast (PADD 3) Regional Outage Review

PADD 3 comprises the southern central states of Alabama, Mississippi, Louisiana, Arkansas, Texas, and New Mexico. The region has 51 operating refineries with combined crude distillation capacity totaling 9.1 million barrels per stream day[3] (b/sd), fluidized catalytic cracking capacity of 3.0 million b/sd, catalytic reforming capacity of 1.9 million b/sd, hydrocracking capacity of 1.1 million b/sd, and coking capacity of 1.6 million b/sd. There are an additional five facilities in the region that are considered refineries but do not have crude distillation and cracking capacities, so are not included in this report's analysis.

The Gulf Coast region is the largest refining center in the United States and is home to slightly more than half of the country's capacity. Data on refinery capacity in PADD 3 are grouped into five refining districts: New Mexico, Texas Inland, Texas Gulf Coast, Louisiana Gulf Coast (which includes coastal portions of Mississippi and Alabama), and North Louisiana-Arkansas (which includes northern Mississippi and Alabama). Regional capacity is concentrated primarily in the Texas Gulf Coast and Louisiana Gulf Coast districts. These two districts have 16 refineries each, with 49% and 39% of regional crude distillation capacity, respectively.

The Gulf Coast region, which has far more refining capacity than is needed to meet the in-region product demand, supplies substantial volumes of petroleum products to other regions, most notably the East Coast and the Midwest.

In the first half of 2016, planned maintenance in the Gulf Coast region is, on average, near the 10-year average. Because the regional inventory levels are well above the 10-year average levels, the supply of petroleum products should be adequate to meet demand.

[3] Stream day capacity is the maximum number of barrels of input that a distillation facility can process within a 24-hour period when running at full capacity under optimal crude and product slate conditions with no allowance for downtime. Barrels per calendar day is a measure of the amount of input that a distillation unit can process in a 24-hour period under usual operating conditions. It takes into account both planned and unplanned maintenance. Stream day capacity is typically about 6% higher than calendar day capacity.

Table 3. Gulf Coast (PADD 3) planned refinery capacity outages

Atmospheric crude distillation

Month	thousand barrels per day			as percentage of capacity		
	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	445	402	374	5%	4%	4%
February	262	371	497	3%	4%	5%
March	329	278	410	4%	3%	5%
April	336	51	237	4%	1%	3%
May	44	119	209	0%	1%	2%
June	0	52	192	0%	1%	2%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Fluidized catalytic cracking

Month	thousand barrels per day			as percentage of capacity		
	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	176	193	142	6%	6%	5%
February	169	321	282	6%	11%	9%
March	104	282	181	3%	9%	6%
April	37	58	79	1%	2%	3%
May	0	75	50	0%	3%	2%
June	83	35	21	3%	1%	1%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Reforming

Month	thousand barrels per day			as percentage of capacity		
	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	111	33	97	6%	2%	5%
February	112	39	91	6%	2%	5%
March	215	35	58	11%	2%	3%
April	58	0	47	3%	0%	2%
May	0	155	53	0%	8%	3%
June	0	165	37	0%	9%	2%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Hydrocracking

	thousand barrels per day			as percentage of capacity		
Month	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	68	24	47	6%	2%	4%
February	45	1	78	4%	0%	7%
March	120	40	50	11%	4%	5%
April	15	81	45	1%	7%	4%
May	0	53	26	0%	5%	2%
June	0	100	28	0%	9%	3%

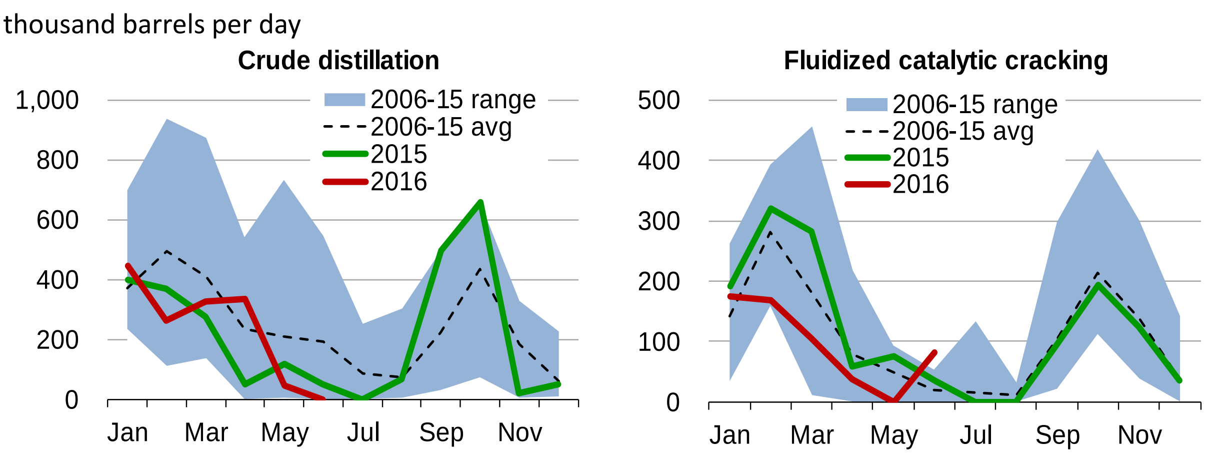
Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

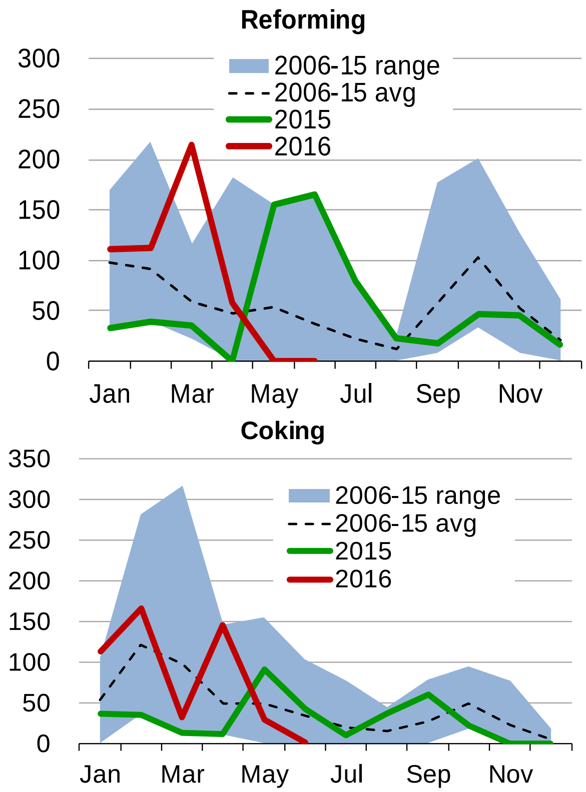
Coking

	thousand barrels per day			as percentage of capacity		
Month	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2015 planned outages	2006-15 average planned outages
January	113	37	53	7%	2%	3%
February	167	36	121	11%	2%	8%
March	33	13	98	2%	1%	6%
April	145	11	49	9%	1%	3%
May	29	92	49	2%	6%	3%
June	2	42	34	0%	3%	2%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Figure 8. Gulf Coast (PADD 3) planned refinery capacity outages

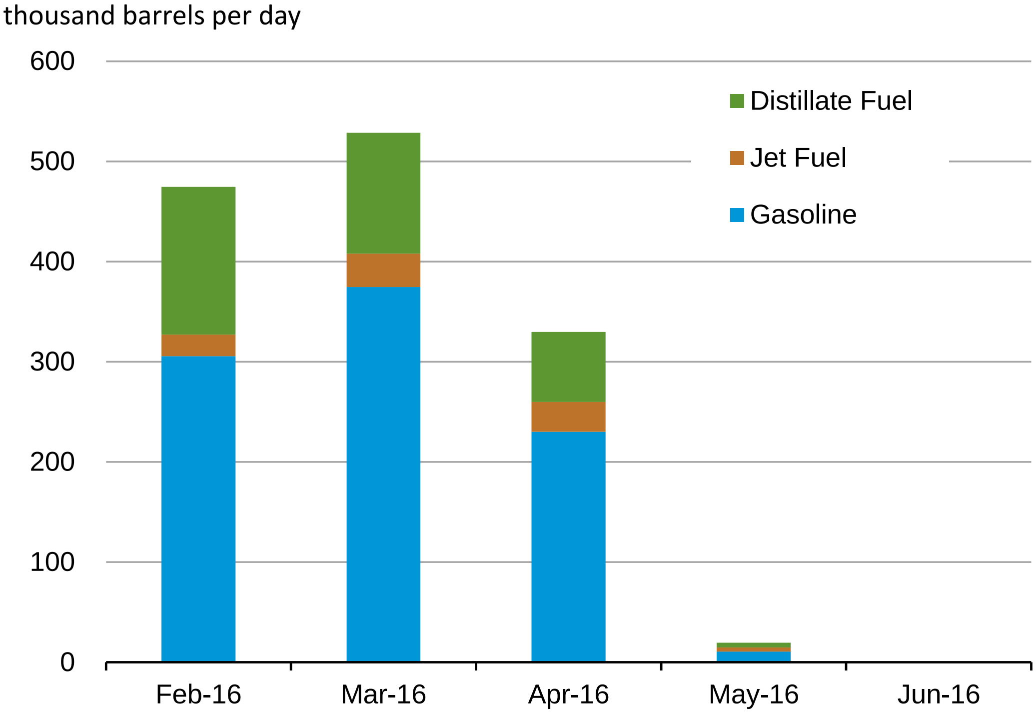




Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Planned maintenance of reforming, hydrocracking, and coking capacities are intermittently above or close to the 10-year maximum, while others are near or below the 10-year average.

Figure 9. Gulf Coast (PADD 3) production losses as a result of planned outages

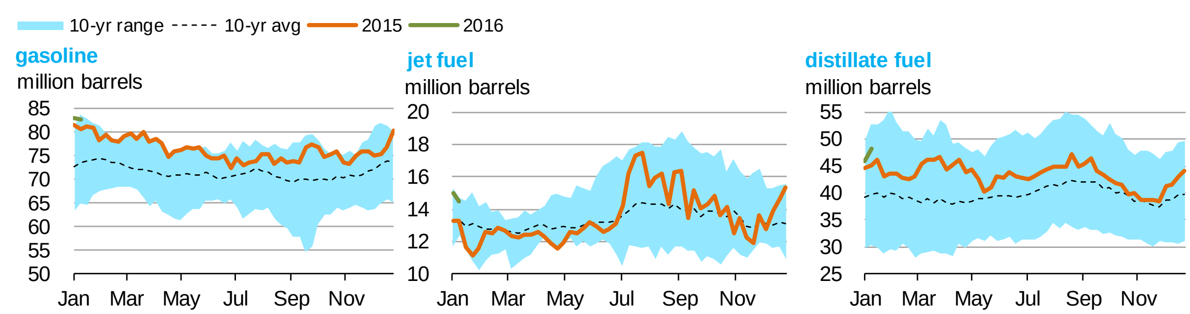


Source: U.S. Energy Information Administration, based IIR data as of January 4, 2016

The outages will result in moderate production loss in petroleum products. From February to April, the expected average losses are 303,000 b/d in gasoline, 28,000 b/d in jet fuel, and 113,000 b/d in distillate fuel (Figure 9).

Gulf Coast inventories are all near or above the 10-year maximum at the beginning of 2016 (Figure 10). The total estimated production loss as a result of the planned outages accounts for 33% of existing gasoline inventory, 18% of jet fuel inventory, and 21% of existing distillate inventory. As a result, there may be a need to divert exports from the U.S. Gulf Coast to domestic markets to offset lost production from the planned outages.

Figure 10. Gulf Coast (PADD 3) petroleum product inventories, 2015-present



Sources: U.S. Energy Information Administration

8. Rocky Mountains (PADD 4) Regional Outage Review

PADD 4, which includes Idaho, Montana, Wyoming, Utah, and Colorado, has 17 operating refineries and the smallest refining capacity of any PADD region in the United States, with combined atmospheric crude distillation capacity of 0.61 million barrels per stream day[4] (b/sd), fluidized catalytic cracking capacity of 0.20 million b/sd, catalytic reforming capacity of 0.13 million b/sd, hydrocracking capacity of 40,000 b/sd, and delayed coking capacity of 79,000 b/sd.

Although refineries in the Rocky Mountain region supply most of the in-region gasoline and distillate demand, the region does receive small volumes of products from refineries in the Midwest and the Gulf Coast, which are possible sources of supplemental supply during a shortage.

The moderate levels of maintenance planned for the Rocky Mountain region in March and April, should not affect product availability as inventories of petroleum products are above the 10-year average, consumption is lower in March and April, and other regions can provide additional supply to markets in PADD 4 if needed.

Table 4. Rocky Mountains (PADD 4) planned refinery capacity outages

Atmospheric crude distillation

	thousand barrels per day			as percentage of capacity		
Month	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**	**2016 planned outages**	**2016 planned outages**	**2006-15 average planned outages**
January	0	0	10	0%	0%	2%
February	11	12	15	2%	2%	3%
March	37	95	45	6%	16%	7%
April	41	53	42	7%	9%	7%
May	0	0	20	0%	0%	3%
June	0	26	28	0%	4%	5%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

[4] Stream day capacity is the maximum number of barrels of input that a distillation facility can process within a 24-hour period when running at full capacity under optimal crude and product slate conditions with no allowance for downtime. Barrels per calendar day is a measure of the amount of input that a distillation unit can process in a 24-hour period under usual operating conditions. It takes into account both planned and unplanned maintenance. Stream day capacity is typically about 6% higher than calendar day capacity.

Fluidized catalytic cracking

	thousand barrels per day			as percentage of capacity		
Month	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2016 planned outages	2006-15 average planned outages
January	0	0	1	0%	0%	0%
February	4	0	5	2%	0%	2%
March	18	26	14	9%	13%	7%
April	31	26	16	15%	13%	8%
May	9	1	9	4%	0%	4%
June	21	0	2	10%	0%	1%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Reforming

	thousand barrels per day			as percentage of capacity		
Month	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2016 planned outages	2006-15 average planned outages
January	0	0	1	0%	0%	1%
February	3	0	3	3%	0%	2%
March	12	0	10	9%	0%	8%
April	14	0	11	10%	0%	8%
May	0	0	3	0%	0%	2%
June	0	0	1	0%	0%	0%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Hydrocracking

	thousand barrels per day			as percentage of capacity		
Month	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2016 planned outages	2006-15 average planned outages
January	0	0	0	0%	0%	0%
February	0	1	0	0%	3%	0%
March	0	0	1	0%	1%	3%
April	0	0	2	0%	0%	5%
May	0	0	0	0%	0%	0%
June	0	0	5	0%	0%	13%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

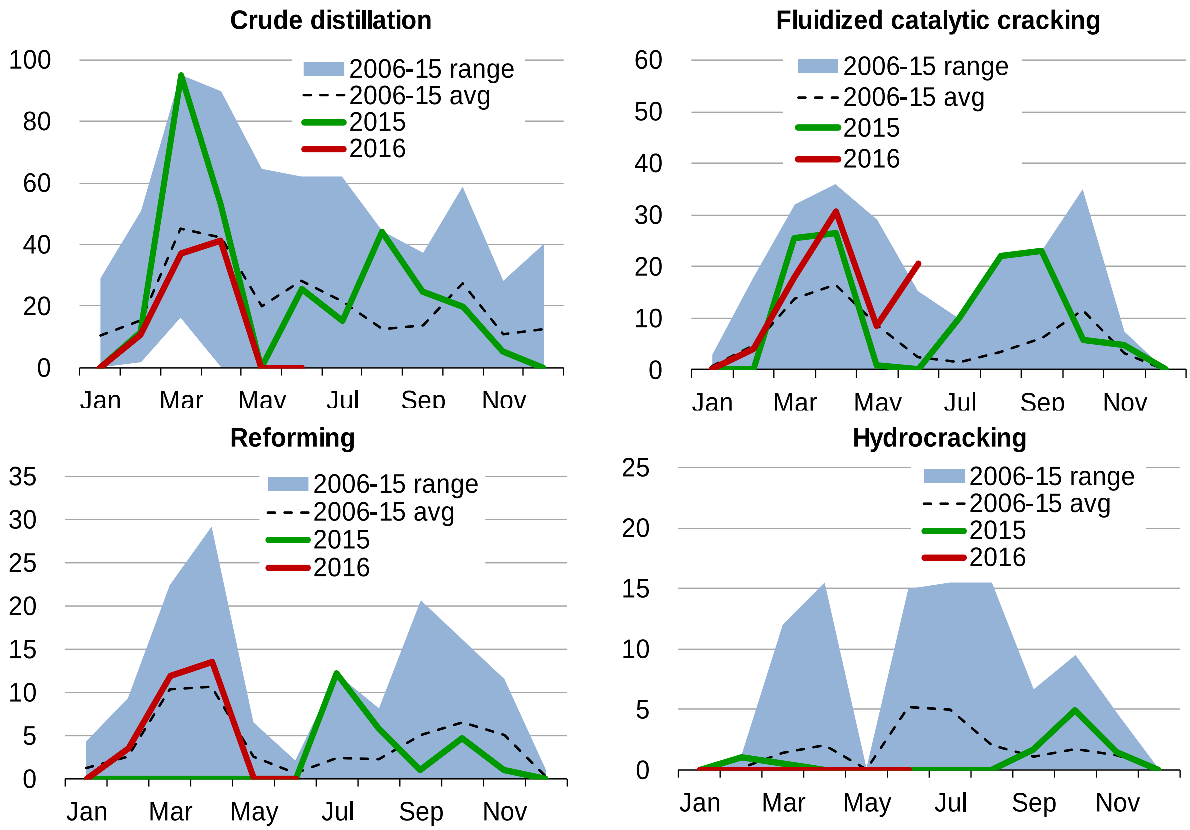
Coking

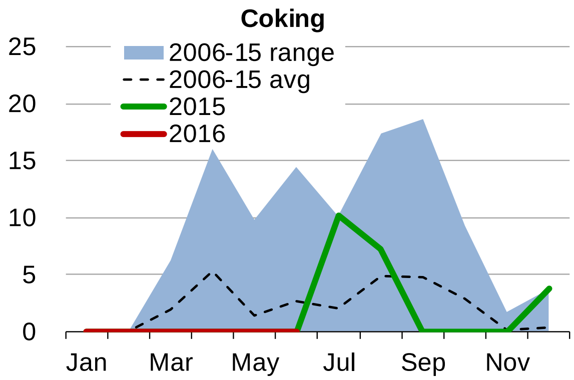
Month	thousand barrels per day			as percentage of capacity		
	2016 planned outages	2015 planned outages	2006-15 average planned outages	2016 planned outages	2016 planned outages	2006-15 average planned outages
January	0	0	0	0%	0%	0%
February	0	0	0	0%	0%	0%
March	0	0	2	0%	0%	2%
April	0	0	5	0%	0%	7%
May	0	0	1	0%	0%	2%
June	0	0	3	0%	0%	3%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Figure 11. Rocky Mountains (PADD 4) refinery capacity outages

thousand barrels per day



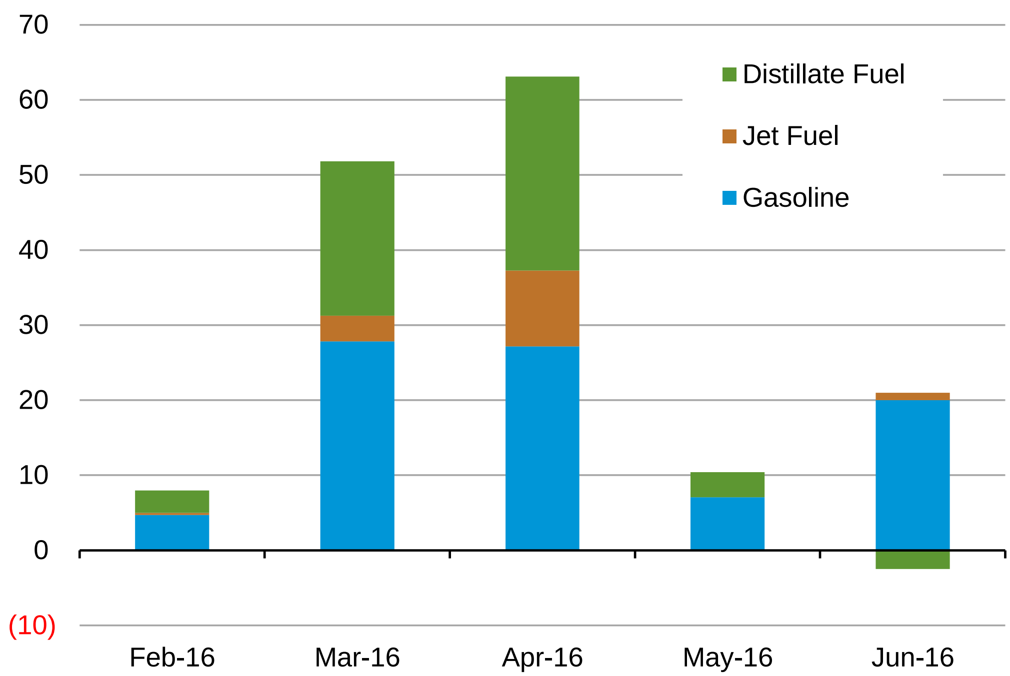


Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Planned outages are concentrated in from March to May (Figure 12).

Figure 12. Rocky Mountains (PADD 4) production losses as a result of planned outages

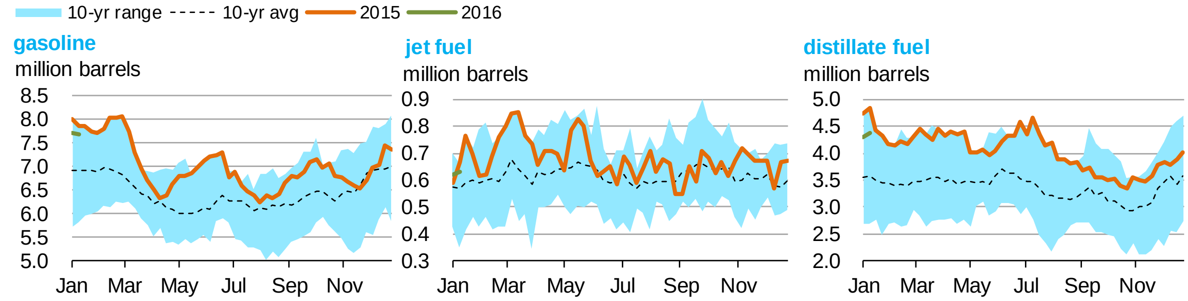
thousand barrels per day



Source: U.S. Energy Information Administration, based IIR data as of January 4, 2016

Total estimated production losses from planned outages account for 34% of gasoline inventory, 71% of jet fuel inventory, and 35% of distillate inventory. The inventory levels for those products were all close to the 10-year maximum as of late January, however, continued supply from other regions will be required to offset lost production from the planned outages.

Figure 13. Rocky Mountains (PADD 4) petroleum product inventories, 2015-present



Sources: U.S. Energy Information Administration

9. West Coast (PADD 5) Regional Outage Review

PADD 5 comprises the western states of California, Nevada, Oregon, Washington, Arizona, Alaska, and Hawaii, and has 30 operating refineries with combined crude distillation capacity 2.8 million barrels per stream day[5] (b/sd), fluidized catalytic cracking capacity of 0.87 million b/sd, reforming capacity of 0.60 million b/sd, hydrocracking capacity of 0.47 million b/sd, and coking capacity of 0.55 million b/sd. California has 17 operating refineries (with 67% of PADD 5 crude distillation capacity) mostly clustered in two refining centers within the state. About 40% of California refinery capacity is in the San Francisco area and the remaining 60% is in the southern part of the state, primarily near Los Angeles. Washington has 22% of PADD 5 crude capacity, and all five of its refineries are near Puget Sound. Alaska has five refineries, making up 6% of PADD 5 crude distillation capacity, and Hawaii, with two operating refineries, has 5% of regional capacity.

On February 18, 2015, the FCC unit at the ExxonMobil refinery in Torrance, California had an unplanned outage because of an explosion. Trade press indicates that the 100,00 b/d FCC unit will remain offline until June 2016, impairing 24% of the FCC capacity in the southern California region, which lacks incoming pipeline capacity for alternative supply of petroleum products. Since the outage, the market has balanced by increasing imports.

PADD 5 began its first-half 2016 refinery maintenance season with the carryover of supply disruption. Market participants will continue to import more petroleum products to the southern California region to alleviate the supply shortage.

Table 5. West Coast (PADD 5) planned refinery capacity outages

Atmospheric crude distillation

	thousand barrels per day			as percentage of capacity		
Month	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**	**2016 planned outages**	**2016 planned outages**	**2006-15 average planned outages**
January	47	0	77	2%	0%	3%
February	207	100	117	7%	4%	4%
March	7	92	111	0%	3%	4%
April	205	120	105	7%	4%	4%
May	215	7	110	8%	0%	4%
June	65	68	73	2%	2%	3%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

[5] Stream day capacity is the maximum number of barrels of input that a distillation facility can process within a 24-hour period when running at full capacity under optimal crude and product slate conditions with no allowance for downtime. Barrels per calendar day is a measure of the amount of input that a distillation unit can process in a 24-hour period under usual operating conditions. It takes into account both planned and unplanned maintenance. Stream day capacity is typically about 6% higher than calendar day capacity.

Fluidized catalytic cracking

Month	thousand barrels per day 2016 planned outages	2015 planned outages	2006-15 average planned outages	as percentage of capacity 2016 planned outages	2016 planned outages	2006-15 average planned outages
January	77	47	88	9%	5%	10%
February	102	73	104	12%	8%	12%
March	45	73	62	5%	8%	7%
April	0	66	42	0%	8%	5%
May	0	0	10	0%	0%	1%
June	0	0	1	0%	0%	0%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Reforming

Month	thousand barrels per day 2016 planned outages	2015 planned outages	2006-15 average planned outages	as percentage of capacity 2016 planned outages	2016 planned outages	2006-15 average planned outages
January	69	33	32	11%	5%	5%
February	42	23	30	7%	4%	5%
March	23	33	43	4%	5%	7%
April	12	81	35	2%	13%	6%
May	17	116	31	3%	19%	5%
June	2	70	17	0%	12%	3%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Hydrocracking

Month	thousand barrels per day 2016 planned outages	2015 planned outages	2006-15 average planned outages	as percentage of capacity 2016 planned outages	2016 planned outages	2006-15 average planned outages
January	55	29	22	12%	6%	5%
February	10	30	31	2%	6%	7%
March	0	10	32	0%	2%	7%
April	13	33	32	3%	7%	7%
May	21	114	37	5%	24%	8%
June	2	50	21	1%	11%	4%

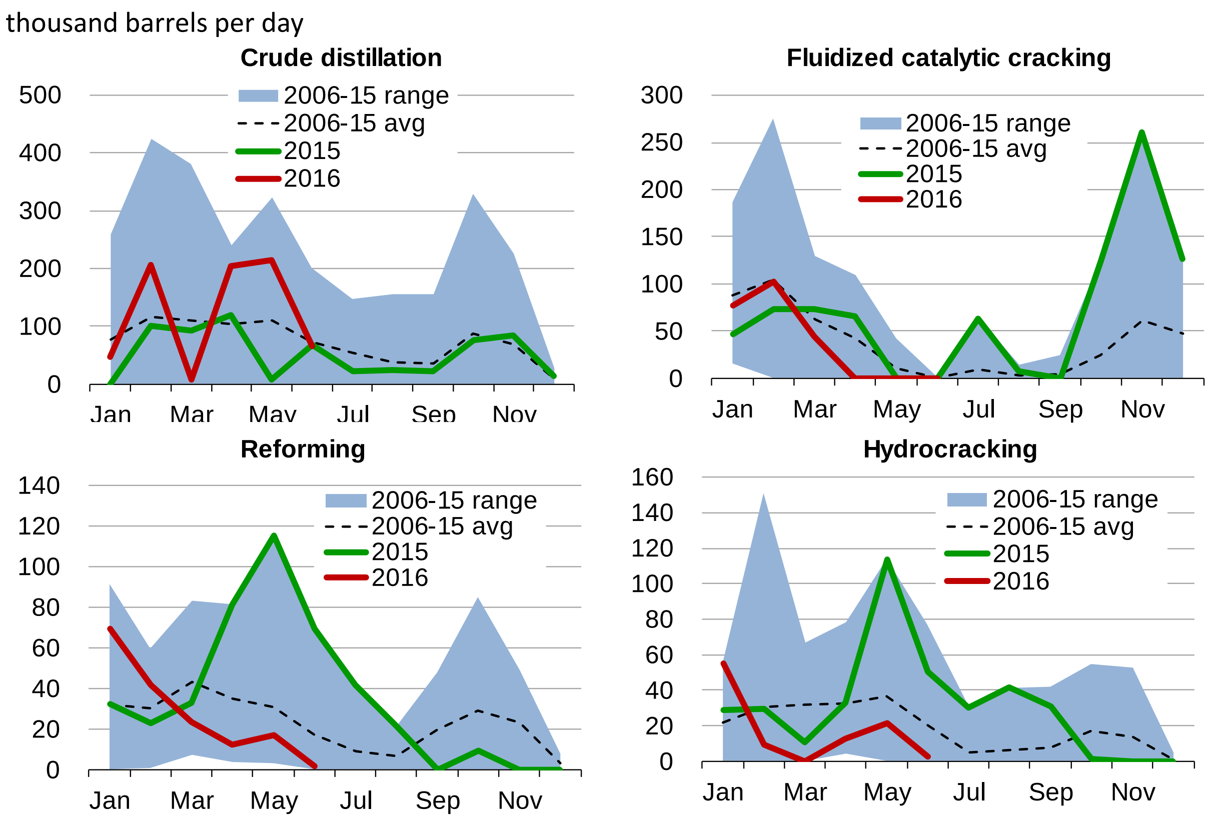
Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

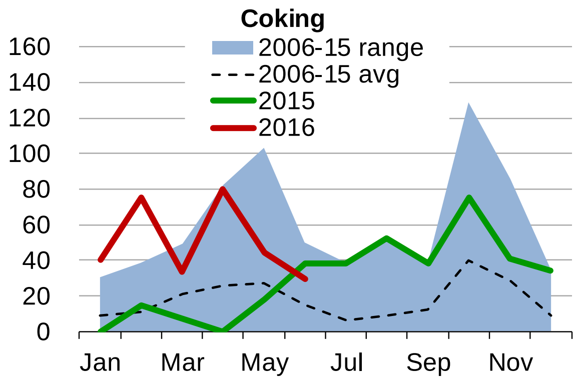
Coking

	thousand barrels per day			as percentage of capacity		
Month	**2016 planned outages**	**2015 planned outages**	**2006-15 average planned outages**	**2016 planned outages**	**2016 planned outages**	**2006-15 average planned outages**
January	40	0	9	7%	0%	2%
February	75	15	11	14%	3%	2%
March	33	7	21	6%	1%	4%
April	80	0	26	14%	0%	5%
May	45	18	27	8%	3%	5%
June	30	39	15	5%	7%	3%

Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Figure 14. West Coast (PADD 5) refinery capacity outages



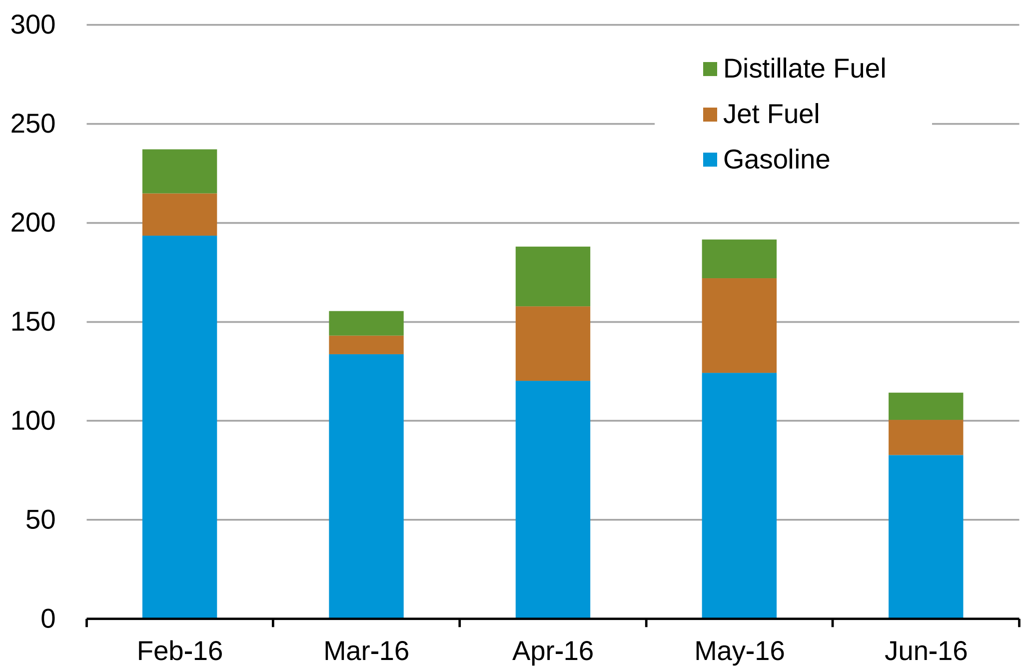


Source: U.S. Energy Information Administration, using IIR data as of January 4, 2016

Between February and June, planned outages will be higher than the 10-year average in coking capacities, and generally near or below the 10-year average in crude distillation, fluidized catalytic cracking, reforming, and hydrocracking capacities.

Figure 15. West Coast (PADD 5) production losses as a result of planned outages

thousand barrels per day

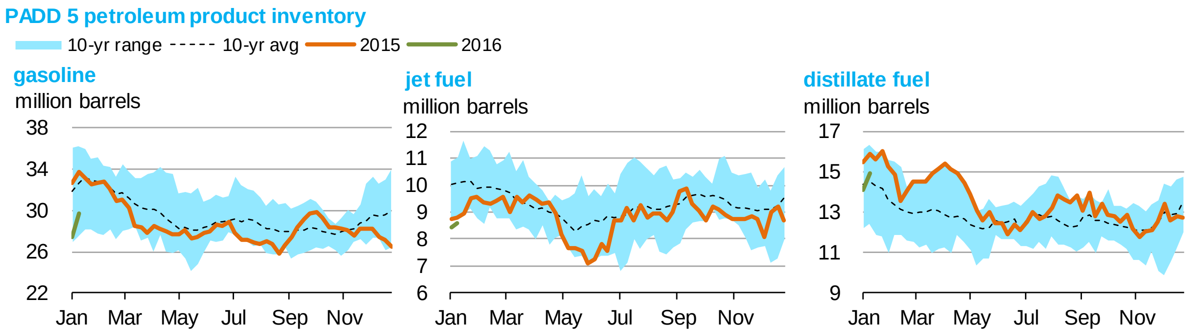


Source: U.S. Energy Information Administration, based IIR data as of January 4, 2016

Because a large share of FCC capacity remains offline from January to June, the total estimated production loss is concentrated in gasoline. From February through June, average production loss of gasoline is 131,000 b/d, and the average losses in jet fuel and distillate fuel are 27,000 b/d and 20,000 b/d, respectively.

The total estimated reduction of petroleum products induced by the outages accounts for 66% of the existing gasoline inventory, 47% of jet fuel inventory, 20% of distillate fuel inventory. Therefore, continued imports of gasoline and jet fuel into the West Coast will be required to provide adequate supplies.

Figure 16. West Coast (PADD 5) petroleum product inventories, 2015-present



Sources: U.S. Energy Information Administration