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Heavy Bets Pay Off for Midwestern Refineries

Growth limited by static demand in PADD 2.

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Data Used in this Publication

- CME Group
- EIA

To discover more about the data sources used, Click Here

Contents

Executive Summary

The story of Midwestern refining since 2010 is one of heavy crude versus shale. Before the shale boom, regional refineries invested heavily in complex coking capacity to process growing supplies of oil sands crude from Canada. Just as that new capacity came on line, a tsunami of light crude hit the region in the shape of a million barrels a day of new Bakken Shale production. As light shale and heavy Canadian barrels competed for pipeline space, refiners were in the catbird seat and enjoyed windfall margins. By 2016, new routes to market opened up for shale crude as pipelines were built and export restrictions lifted. Midwestern light crude refining margins fell to the same level as Gulf Coast rivals. Continued congestion from delays in pipeline capacity built across the Canadian border has kept heavy crude prices lower and margins stronger, rewarding refiners that invested in coking capacity.

Two major challenges lie ahead for Midwestern refiners. First, the heavy crude refineries face the threat of lower Canadian oil sands production, which could leave them paying more for dwindling supplies. Second, refined product demand is static in the landlocked Midwestern market, placing a lid on new capacity growth. This outlook reviews crude supply and demand, refinery operations, refined product supply and demand, and refining margins in the Midwest.

Key Takeaways

- The 26 refineries in the Midwest PADD 2 region, with 3.9 mmb/d capacity, process 300 mb/d more crude today than they did in 2010.
- Despite booming light shale crude production in the region, refiners have increased processing of Canadian heavy crude imports over the past six years.
- The crude shale boom bought windfall margins to all regional refiners between 2012 and 2014, but light crude margins now only match Gulf Coast levels.
- Margins for heavy crude processing have beaten light crude consistently since 2012 and remain healthy.
- Only one large independent refiner, Marathon, has invested heavily to take advantage of shale crude production from the Utica Basin in Ohio.
- PADD 2 refiners have increased their local market share to supply 87% of the transport fuels the region consumes, but further growth is challenged by static demand.
- A new 55 mb/d refinery planned in North Dakota could start construction in October, but prospects for its success rely on securing markets for its products.
- Ten refineries with 1.9 mmb/d of capacity receive their crude through direct pipeline connections to the Cushing, Oklahoma, storage and trading hub.

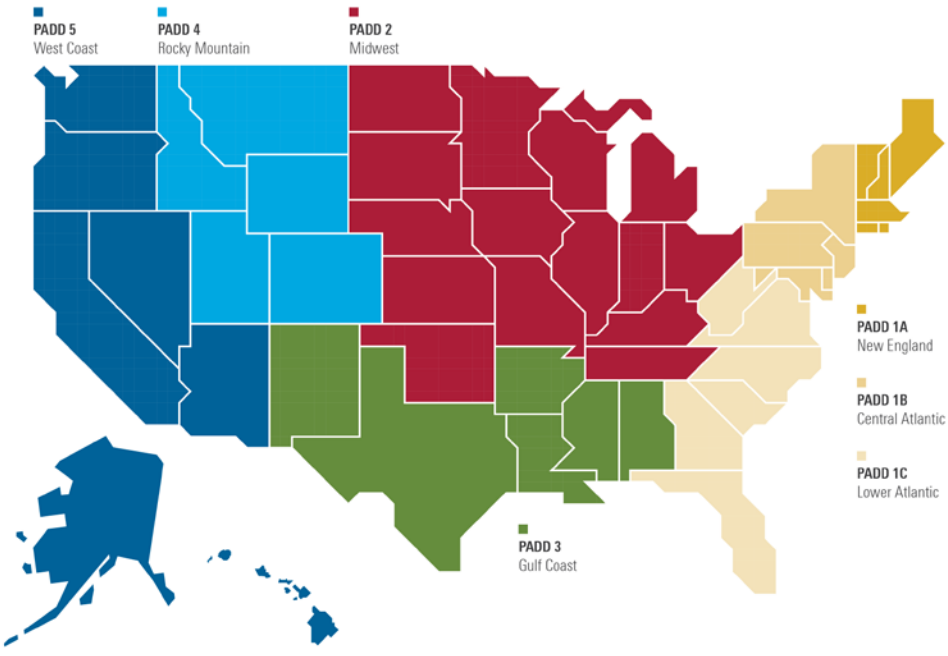
U.S. Refining Overview

In our June note on refinery performance ("U.S. Refiners Lose Crude Price Advantage"), we described how U.S. refiners enjoyed record margins over 2011-15 as a result of advantages bestowed by the dramatic increase in domestic crude production during the shale boom. Domestic crude production increased 75% from 5.5 mmb/day in January 2011 to a peak of 9.6 mmb/d in April 2015 before declining 10% (in response to lower prices) to 8.6 mmb/d in September 2016 and recovering since in response to higher prices to 8.8 mmb/d in December 2016 (monthly data according to the U.S. Energy Information Administration). Two competitive advantages underpinned record refinery performance during the shale boom. First, access to lower-priced crude feedstock, primarily from shale, as well as cheap natural gas fuel for processing, kept costs low. Second, increased demand for refined products, fueled by an export boom on the Gulf Coast, provided an outlet for refiners processing higher volumes of crude.

The first of these two advantages has now all but disappeared, as U.S. crude prices are level with international competitors. The second—growing refined product exports—has continued. As a result, U.S. refining margins are down in 2017 compared with their peak in 2012, but they continue to outperform international competitors.

This is the third in a series of outlooks for each of the U.S. refining regions that we will publish in coming months. The five refining regions covered are based on the Department of Energy Petroleum Administration for Defense Districts that underlie EIA data reporting and analysis. The five PADD regions are shown in Exhibit 1.

Exhibit 1 U.S. PADD Refining Regions



Source: EIA, Morningstar

As outlined in the first outlook in this series ("East Coast Refining After the Shale Boom"), our refinery analysis focuses on 115 plants in the Lower 48 states and Hawaii that process crude oil to manufacture transportation fuels. We do not include an additional 23 plants listed by EIA in its biannual refining capacity review, because they are in Alaska or they primarily produce lubricants or asphalt rather than transport fuels. Total operating capacity for the 114 plants is 18.0 mmb/d. The regional breakdown of refining capacity is 1.2 mmb/d in PADD 1 (East Coast), 3.9 mmb/d in PADD 2 (Midwest), 9.8 mmb/d in PADD 3 (Gulf Coast), 0.7 mmb/d in PADD 4 (Rockies), and 2.4 mmb/d in PADD 5 (West Coast and Hawaii). Two thirds of capacity is in the combined Gulf Coast (55%) and Midwest (21%) regions.

For the purpose of this analysis, we assigned refinery ownership to one of nine categories (not counting joint ventures as separate categories) shown in Exhibit 2. Of these categories, 70% (by capacity) belong to large independents and major oil companies. In order of capacity, the large independents are Valero, Phillips 66, Marathon Petroleum, Tesoro, PBF Energy, and HollyFrontier. The major oil companies in order of capacity are ExxonMobil, Royal Dutch Shell, Chevron, BP, and Total. There are six smaller independent refiners with 10% of capacity among them, four national oil companies (PDVSA, Aramco/Motiva, Pemex, and Petrobras) with 9% of capacity, 13 privately owned companies with 15 plants and 6% of capacity, five private equity firms owning six refineries, two independent producers, three joint ventures, two cooperatives, and one airline.

These refineries vary considerably in capacity and complexity. For example, of the 115 refineries considered, 52% have coker units that process heavy crude (for more on heavy crude processing, see our August 2016 note "Gulf Coast Refiners Enjoy Higher Margins From Processing Heavy Crude"). About 10% are configured to process the ultralight crude oils known as condensate, discussed in our July note covering light crude capacity on the Gulf Coast ("Gulf Coast Refiners Penalized for Running the Lights") and our September note on Kinder Morgan's condensate splitter (see "Kinder Morgan Splitter Runs at 71% Throughput").

Exhibit 2 U.S. Refiner Categories by Capacity

Category	Refineries	Capacity b/d
Large Independent	48	7,914,950
Major Oil	17	4,336,600
Privately Owned	15	1,110,800
Small Independent	14	1,113,000
Private Equity	6	557,000
National Oil Co.	5	1,477,000
Cooperative	3	173,000
Large Ind/Producer JV	2	482,000
Producer	2	255,000
Airline	1	190,000
Major/National Oil Co.	1	286,000
Major/Producer	1	153,000
	Total	18,048,350

Source: EIA, Morningstar

Midwestern Refining

The 26 refineries in the Midwest have 3.9 mmb/d of primary crude processing capacity. They are located in 11 states and serve customers in the15 states that constitute PADD 2. In 2016, these refineries handled about 22% of the average 16.5 mmb/d of crude processed by U.S. plants. Exhibit 3 lists the refineries in order of operating capacity.

Exhibit 3 PADD 2 Refineries by Capacity

Name	State	Owner	Capacity b/d
Whiting	IN	BP	413,500
Wood River	IL	P 66/Cenovus JV	336,000
St. Paul Twin Cities	MN	Flint Hills Resources	290,000
Catlettsburg	KY	Marathon	273,000
Joliet	IL	ExxonMobil	239,000
Robinson	IL	Marathon	231,000
Ponca City	OK	Phillips 66	200,000
Memphis	TN	Valero	190,000
Citgo Lemont	IL	PDVSA	175,940
Toledo PBF	OH	PBF Energy	160,000
Tulsa (East & West)	OK	Holly Frontier	155,300
Toledo	OH	BP/Husky JV	153,000
Lima	OH	Husky	152,000
El Dorado	KS	Holly Frontier	138,000
Detroit	MI	Marathon	132,000
Coffeyville	KS	CVR	115,000
Canton	OH	Marathon	93,000
St Paul Park	MN	Tesoro	88,900
Ardmore	OK	Valero	86,000
Mcpherson	KS	CHS	86,000
Mandan	ND	Tesoro	74,000
Wynnewood	OK	CVR	70,000
Calumet Superior	WS	Calumet	38,000
CountryMark	IN	CountryMark	27,100
Dakota Prairie	ND	Tesoro	19,500
Continental	KY	Continental	5,500
		Total	3,941,740

Source: EIA, Morningstar

The majority of refining capacity—2.1 mmb/d or 54%—is operated by large independents followed by majors with 0.65 mmb/d and less than 10% each for smaller categories (Exhibit 4).

Exhibit 4 PADD 2 Refiner Categories by Capacity

Refiner Category	Capacity b/d	% Total Cap
Large Independent	2,130,700	54%
Major	652,500	17%
Large Indy / Producer	336,000	9%
Small Independent	228,500	6%
National Oil Co	175,940	4%
Major / Producer	153,000	4%
Producer	152,000	4%
Coop	113,100	3%
Total	3,941,740	

Source: EIA, Morningstar

The largest owner of Midwest capacity is Marathon with 0.7 mmb/d at four refineries followed by BP with 413 mb/d at the Whiting, Indiana, refinery and 50% of the 153 mb/d Wood River, Illinois, refinery (a joint venture with Husky). Phillips 66 is third in capacity, owning one refinery in Ponca City, Oklahoma, and 50% of a joint venture with Canadian producer Cenovus at Wood River. Exhibit 5 lists the refiners by capacity.

Exhibit 5 PADD 2 Refiners by Capacity

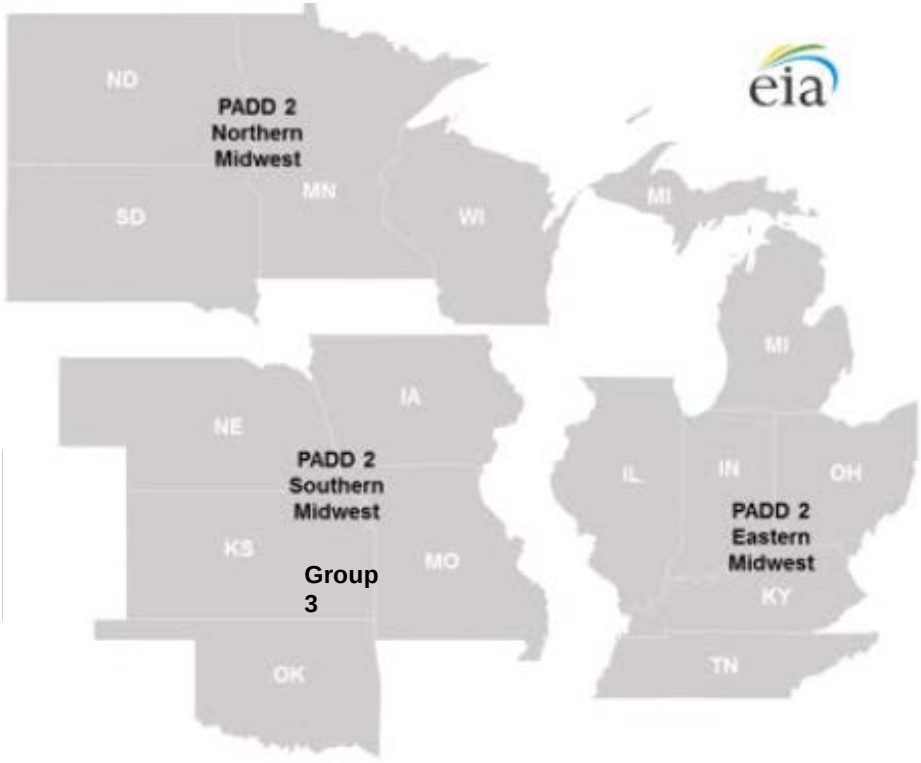
Owner	Capacity b/d
Marathon	729,000
BP	413,500
P 66/Cenovus JV	336,000
Holly Frontier	293,300
Flint Hills Resources	290,000
Valero	276,000
ExxonMobil	239,000
Phillips 66	200,000
CVR	185,000
Tesoro	182,400
PDVSA	175,940
PBF Energy	160,000
BP/Husky JV	153,000
Husky	152,000
CHS	86,000
Calumet	38,000
Country Mark	27,100
Continental	5,500
Total	3,941,740

Source: EIA, Morningstar

PADD 2 Refining Districts

The Energy Information Administration divides PADD 2 into three refining subdistricts (Exhibit 6). The largest of these is the Eastern Midwest, made up of Indiana, Illinois, Kentucky, Tennessee, Michigan, and Ohio. The Eastern Midwest has 14 refineries with 65% of PADD 2 operating capacity. The Southern Midwest district (also known as Group 3) is made up of Oklahoma, Kansas, Nebraska, Missouri, and Iowa and has seven refineries with 22% of capacity. The Northern Midwest district contains Minnesota, Wisconsin, North Dakota, and South Dakota and has five refineries with 13% of capacity.

Exhibit 6 PADD 2 Refining Districts



Source: EIA, Morningstar

Refinery Crude Supply

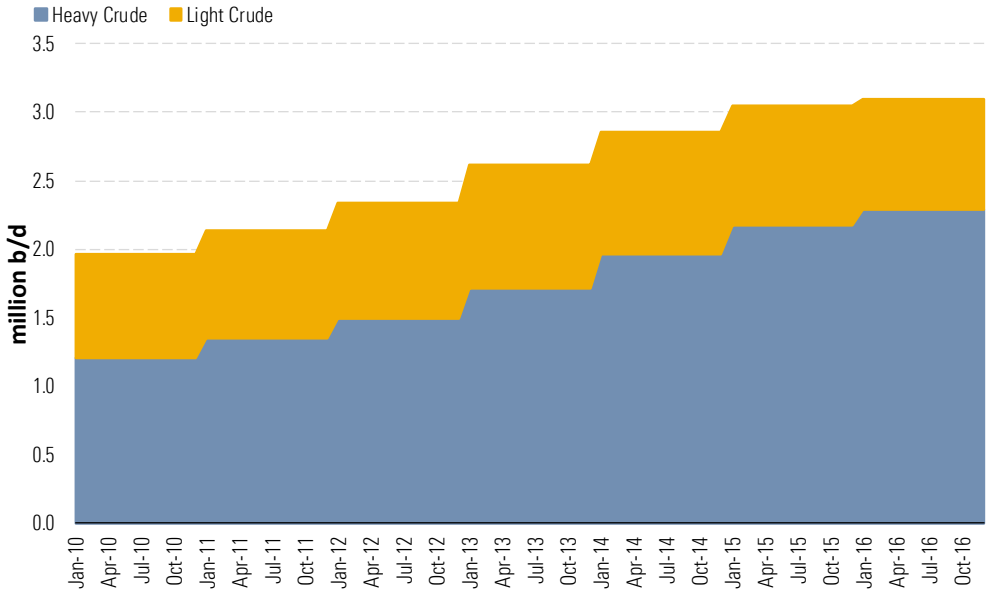
PADD 2 refineries source crude feedstock from Canadian imports and domestic production. Domestic production comes from both inside and outside of PADD 2. We discuss each of these sources below.

Canadian Crude

Canadian crude production averaged 3.9 mmb/d in 2016, according to the National Energy Board. Most Canadian crude originates from the Western Canadian Sedimentary Basin, either as heavy crude extracted using conventional techniques or as heavy bitumen extracted using enhanced recovery from oil sands (see our recent note "Lower For Longer"). Some of the heavy bitumen is upgraded into light synthetic crude oil close to the wellhead. If this SCO is counted as light output, commercial Canadian

production is an even mix of light and heavy grades. The up-front cost to produce SCO has not justified new investment in the past several years, meaning that less bitumen is upgraded and overall crude output is getting heavier. The volume of heavy bitumen crude produced increased from an average 39% of the total in 2010 to 49% in 2016. Over the seven years between 2010 and 2016, NEB estimate Canada exported between 69% and 81% of crude production with domestic refineries consuming a fairly static 2 mmb/d. Because domestic refineries process mostly light crude, exports have a bias to heavy, which averaged 74% or 2.3 mmb/d of the total 3.1 mmb/d exported in 2016 (Exhibit 7).

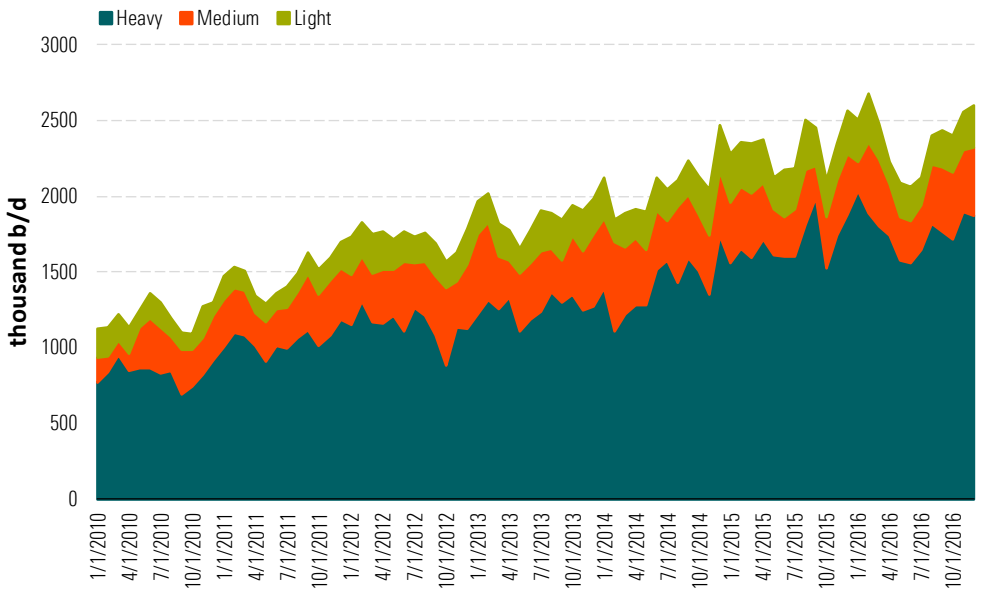
Exhibit 7 Canadian Crude Exports by Grade



Source: NEB

About 99% of Canadian crude exports are delivered to U.S. refineries, with about three fourths headed to PADD 2—77% of the total on average in 2016, according to EIA. Most of the rest goes to Pacific Northwest refineries (see our January 2016 note "Pacific Northwest Refineries: Cheap Crude and a Captive Market") with a small but growing volume headed to Gulf Coast refineries. Exhibit 8 shows monthly EIA data for Canadian crude imports to PADD 2 from 2010 to 2016, broken down by type. PADD 2 doubled imports of Canadian crude from 1.2 mmb/d to 2.4 mmb/d during the seven-year period, and most of the volume was heavy crude (75% in 2016).

Exhibit 8 Canadian Crude Imports to PADD 2 by Grade



Source: EIA, Morningstar

Canadian crude is primarily delivered to PADD 2 refineries by pipeline from Western Canada, although smaller volumes are shipped by rail. The three major pipeline systems that deliver crude from Canada to the Midwest are listed in Exhibit 9. Among them, they can ship up to 3.7 mmb/d.

Exhibit 9 Canadian Pipelines to PADD 2

Pipeline	Owner	Capacity mb/d	U.S. Deliveries
Enbridge Mainline	Enbridge	2,850	Various Midwest States around Great Lakes, East to Pennsylvania, Southwest to Cushing, OK then south to Gulf Coast
Keystone	TransCanada	590	Cushing or Patoka
Spectra Express-Platte	Enbridge	280	Guernsey, WY then Wood River, IL
	Total	3,720	

Source: Company presentations, Morningstar

Canadian crude production continues to expand, despite the crude price crash in 2015 that reduced new investment but not output from existing or under-development plants ("Lower For Longer"). At the same time, export pipeline new build and expansion plans out of Canada have been delayed by slow permitting processes, including the initial denial and subsequent refusal of a presidential border crossing permit for the Keystone XL project. The result has been a constrained system with demand for pipeline transport exceeding available capacity. Canadian producers have had to accept discounted prices for their crude delivered to the United States in order to secure pipeline space. Some producers have shipped crude using more expensive rail options in order to circumvent pipeline congestion. As we discuss in the refining margins section, the net result is that Canadian heavy crude has been and

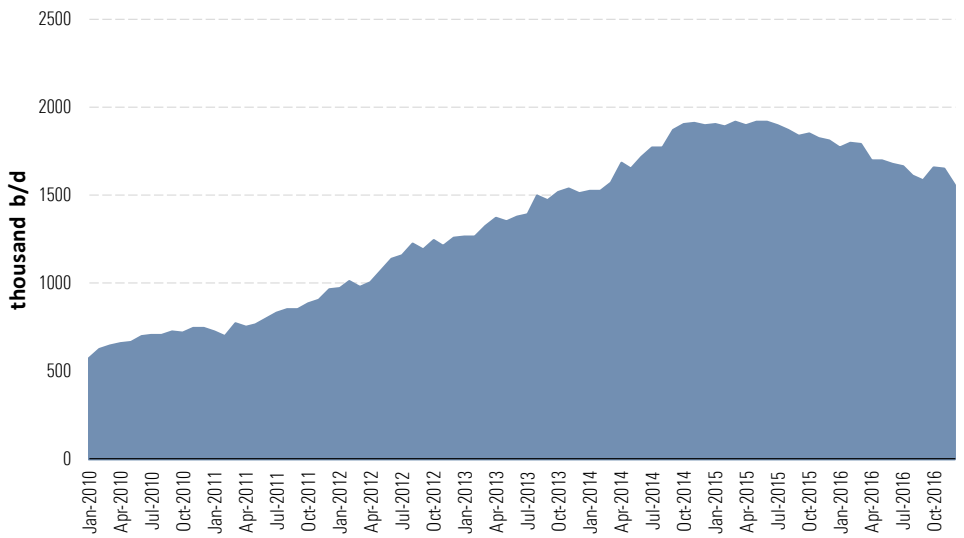
continues to be available to PADD 2 refiners at prices considerably below those paid by Gulf Coast refiners for equivalent imported grades from Venezuela and Mexico.

Domestic Crude

PADD 2 Production

The big PADD 2 crude production story over the past seven years is the Williston Basin Bakken Shale formation, where output expanded by about a million barrels a day, from 250 mb/d in January 2010 to a peak of 1.26 mmb/d in December 2014 (according to EIA). Since then, Bakken output has retreated to less than 1 mmb/d in the face of lower prices and higher costs to market but is expected to recover later in 2017 with new drilling. Aside from North Dakota, new shale production in PADD 2 has come from Oklahoma, where output jumped threefold from 153 mb/d in January 2010 to 473 mb/d in March 2015 and still exceeds 400 mb/d (December 2016) in the face of lower prices. The Oklahoma SCOOP and STACK crude plays have attracted continued investment from producers as well as midstream developers building pipelines to the nearby Cushing hub. A third PADD 2 state with increased crude production is Ohio, home to the liquids window of the Utica Shale formation. Production in the Utica—mostly consisting of ultralight crude known as condensate—jumped sixfold from 13 mb/d in January 2010 to 79 mb/d in December 2015, falling back to 49 mb/d at the end of 2016. All told, PADD 2 crude production expanded by 1.3 mmb/d between 2010 and 2015 and even after some decline remained nearly 1 mmb/d higher at the end of 2016 than it was in 2010 (Exhibit 10).

Exhibit 10 PADD 2 Crude Production



Source: EIA

Domestic Production Outside PADD 2

In addition to 1 mmb/d of new production inside PADD 2, U.S. domestic production expanded elsewhere during the past seven years, primarily in shale. The most accessible of these shale boom supplies for PADD 2 refiners are those from the West Texas Permian, where output increased by 1.2 mmb/d, from 0.9 mmb/d in January 2010 to 2.1 mmb/d in December 2016. Permian crude is delivered into PADD 2 via three major pipeline systems: the Plains-operated Basin pipeline into Cushing, the Occidental Centurion pipeline into Cushing, and the Energy Transfer Mid-Valley pipeline, which delivers crude through the Midwest to Michigan.

Crude production has also increased in the Rockies (PADD 4) from the Niobrara formations located in the Colorado Denver Julesburg and Wyoming Powder River basins. These deliver crude to Cushing and Wood River by pipeline.

Congested Crude Distribution System

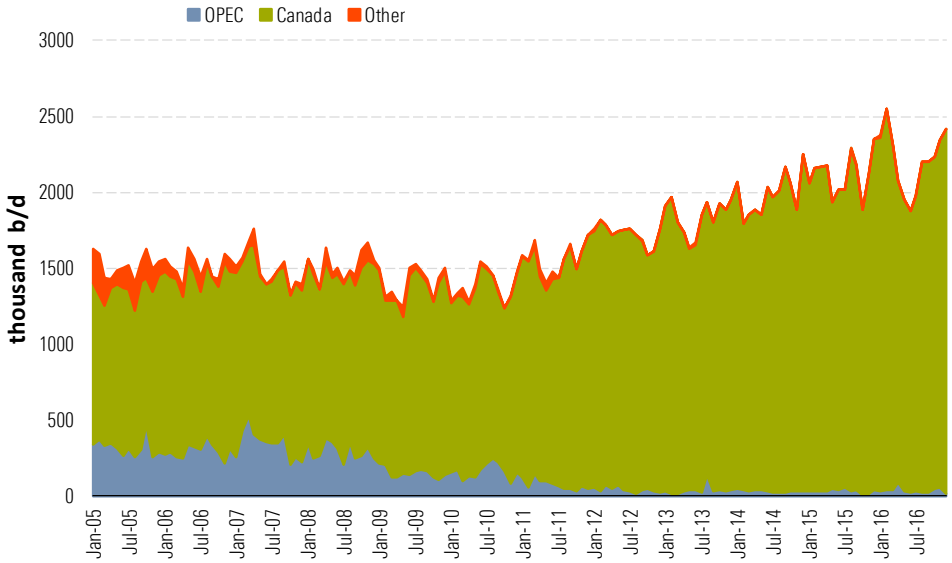
Abundant supplies of inland shale crude produced in PADD 2 and from the Rockies (PADD 4) rapidly overwhelmed the existing Midwestern crude distribution system in 2012. New shale crude had to contend for pipeline space with increased supplies from Canada on pipelines planned to just accommodate Canadian imports. Because pipelines typically take three years from drawing board to in-service, the congestion could not be resolved immediately. As a result, inventory at the Cushing storage hub built up rapidly, and shale producers found their supplies landlocked. They searched for alternative routes to market but in the meantime had to accept price discounts to secure limited pipeline space. PADD 2 refiners found themselves at the center of a perfect storm of abundant cheap crude supplies. Since refined product prices are largely set outside the region at the Gulf Coast, the result was a period of windfall high margins for PADD 2 refiners.

It was ironic that booming domestic light crude shale supplies arrived at a time when the majority of the larger PADD 2 refineries had just completed significant investment in upgrading their plants to process more heavy Canadian imports.

Non-Canadian Imports

As a consequence of increased imports of heavy crude from Canada and increased consumption of domestic shale crude, PADD 2 refiners have reduced crude imports from the rest of the world to a trickle—an average of just 39 mb/d from OPEC in 2016, according to EIA. Exhibit 11 shows PADD 2 imports since 2005, illustrating the dominance of Canadian supplies since 2012.

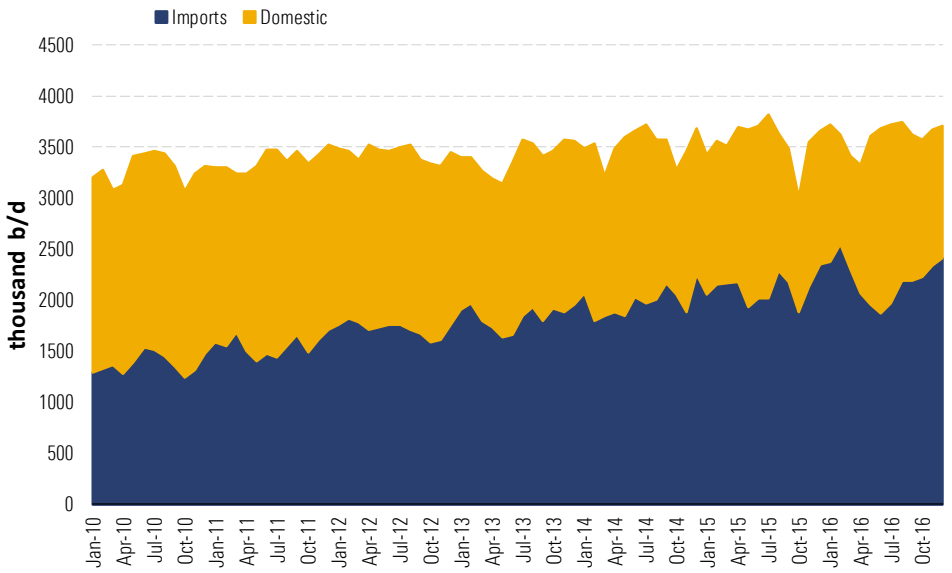
Exhibit 11 PADD 2 Crude Imports by Source



Source: EIA

The overall crude picture for PADD 2 during the seven years between 2010 and 2016 shows Canadian imports increasing by 1.1 mmb/d at the expense of domestic feedstock. The volume of crude that refineries processed did not match the increase in crude imports. Over the same period, PADD 2 crude processed increased only 0.5 mmb/d (Exhibit 12). In other words, the slate of crude processed by PADD 2 refiners became increasingly heavy even in the midst of the domestic shale boom.

Exhibit 12 PADD 2 Crude Supply Mix



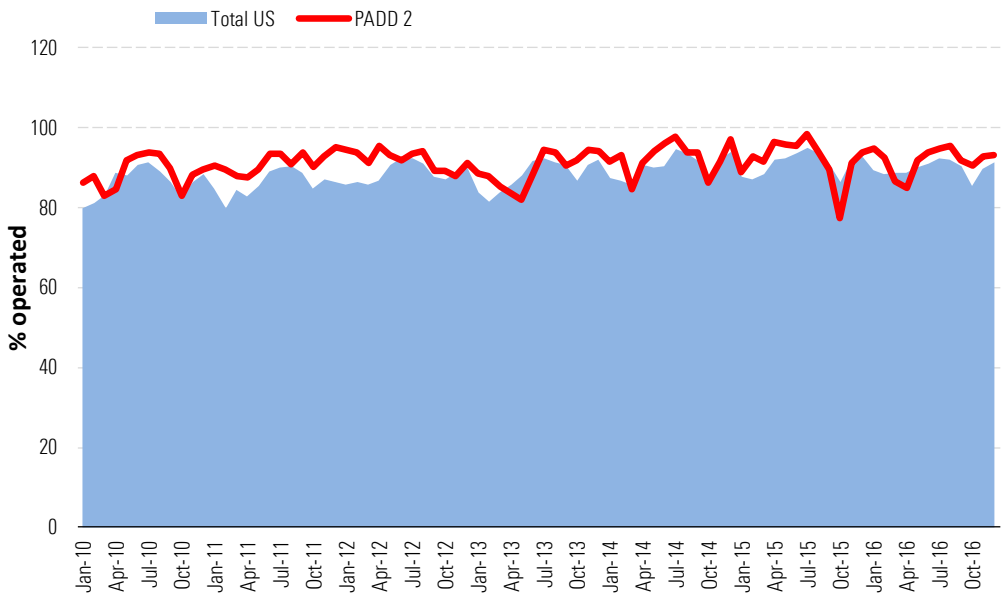
Source: EIA, Morningstar

Refinery Capacity and Operation

PADD 2 refinery operating capacity increased by 218 mb/d, or nearly 6%, to 3.9 mmb/d between 2010 and 2016, according to EIA annual survey data. With one exception—a small new refinery in North Dakota—the increase represented expansions to existing capacity. Yet these expansions were relatively small during a period when (as we shall see) margins were at record levels. Refiners preferred to invest in making existing capacity more productive by adding heavy crude processing capacity to extract more value from the barrel.

They also operated plants more intensely than the U.S. average over this period. Exhibit 13 shows total monthly U.S. refinery operation expressed as a percentage of available capacity (red line) compared with PADD 2 refineries (blue line) between 2010 and 2016. On average, PADD 2 refineries operated at 90% or more of operable capacity over the period. The national average operating percentage was 1%-2% lower over the same period.

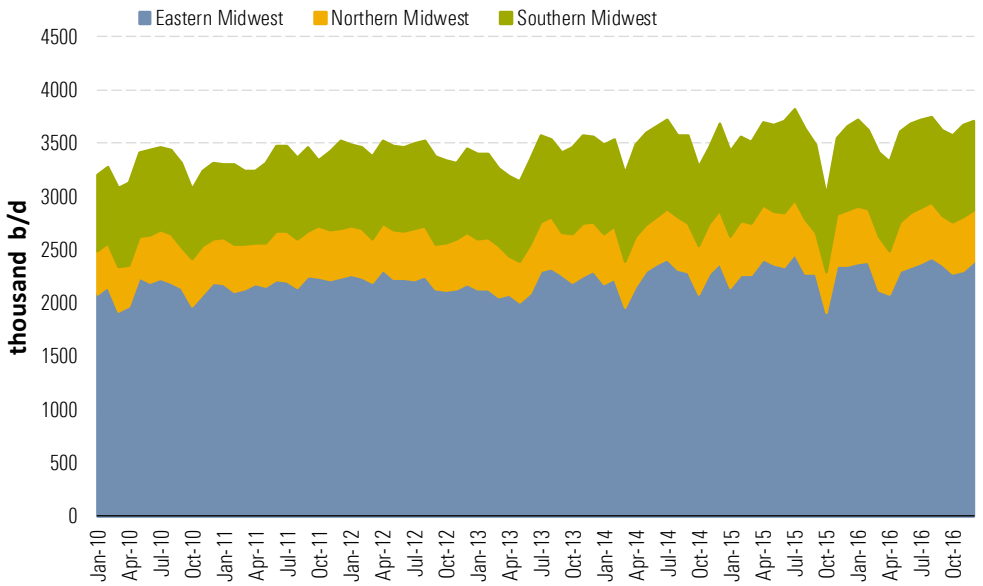
Exhibit 13 PADD 2 Refinery Operation Intensity



Source: EIA, Morningstar

Total crude processed through primary distillation increased by 300 mb/d, from an average 3.3. mmb/d in 2010 to 3.6 mmb/d in 2016. Within PADD 2, the breakdown by refining district over the period fell in line with relative capacity, with the largest Eastern Midwest accounting for 64% of throughput, the Southern Midwest 23%, and the Northern Midwest 13% (Exhibit 14). In terms of intensity, the five refineries in the Northern Midwest operated at a very high monthly average 98% of capacity over the seven-year period. The seven Southern Midwest refineries operated at a monthly average 95% of capacity, and the 14 Northern Midwest refineries ran at 90%.

Exhibit 14 PADD 2 Refinery Operation Intensity by District



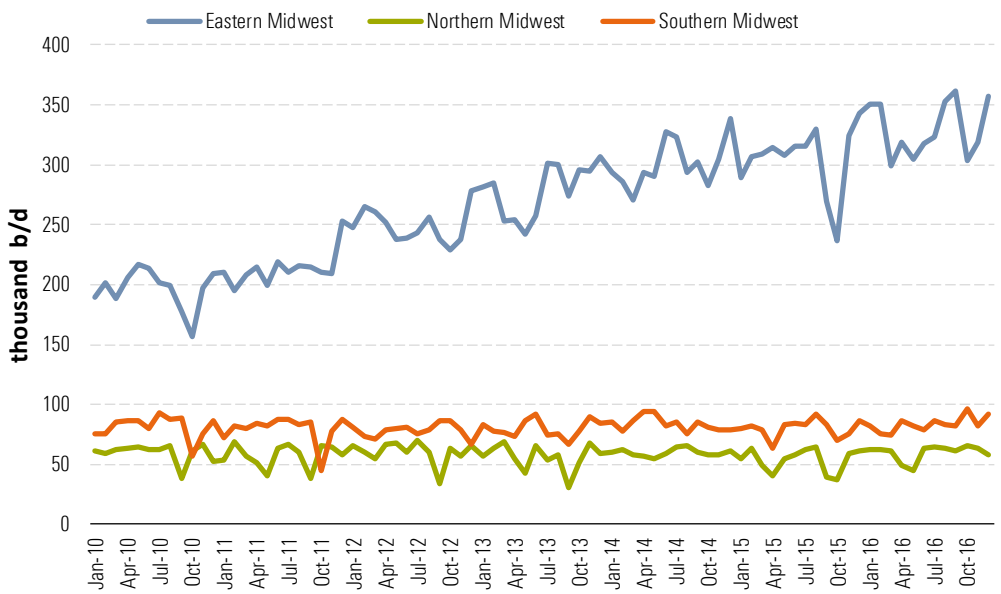
Source: EIA, Morningstar

Crude Slate

As noted already, the slate of crude that PADD 2 refiners processed over this period grew heavier. EIA estimates that the average degrees American Petroleum Institute gravity (a petroleum density scale where water = 10 and higher numbers denote lighter crude) for crude processed in PADD 2 fell from 33.0 in 2010 to 32.5 in 2016. The change reflected increasing heavy Canadian imports.

Within PADD 2, refineries in the Southern Midwest—closer to Cushing—processed a lighter crude slate with an average 37 API in 2016. Eastern Midwest refineries consumed a heavier slate, averaging 31.6 API in 2016. The heavier slate in the East reflects a higher concentration of tertiary coking capacity in that district. Coking units break down heavier fuel oil from secondary crude processing into lighter transport fuels. Coking capacity in the Eastern Midwest increased over the seven-year period from 196 mb/d in 2010 to 330 mb/d in 2016 while coking capacity in the Southern and Northern districts remained flat (Exhibit 15). PADD 2 coker throughput on average increased from 17% of the U.S. total in 2010 to 20% in 2016. In comparison, PADD 3 had an average 56% of total U.S. coker throughput in 2010 and 57% in 2016.

Exhibit 15 PADD 2 Refinery Coker Capacity by District



Source: EIA, Morningstar

In summary, PADD 2 refiners processed more heavy crude and increased their coker capacity and throughput in the past six years, increasing their reliance on Canadian imports. This trend was most pronounced in the Eastern Midwest district.

Refined Products

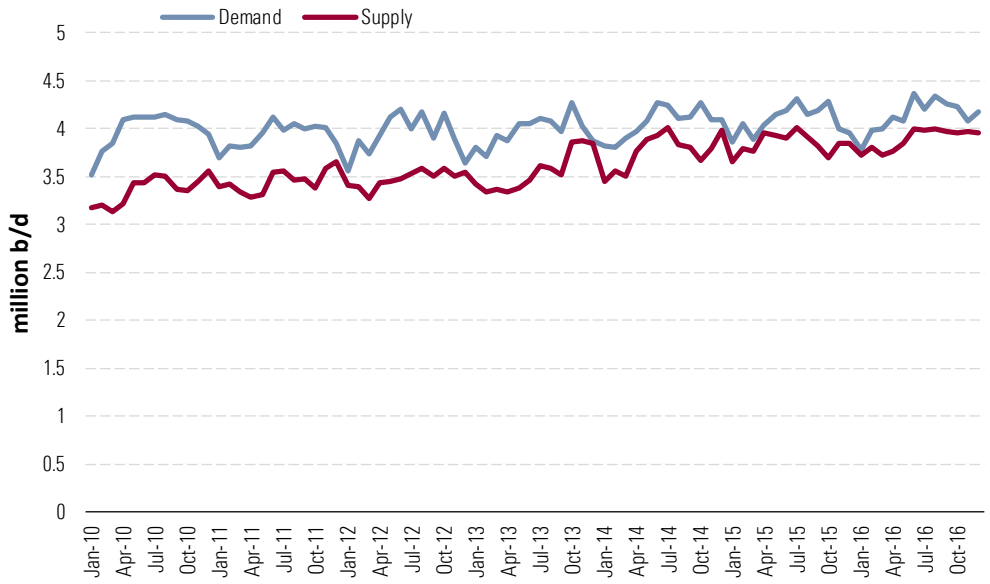
Transport Fuel Supply and Demand

PADD 2 demand for refined transport fuels (gasoline, diesel, and jet kero) increased from an average 3.5 mmb/d in 2010 to 4.2 mmb/d in 2016 (blue line in Exhibit 16). During the same period, transportation fuel supply from regional refineries increased at a slightly faster pace, from 3.2 mmb/d in 2010 to 4.0 mmb/d in 2016 (red line in Exhibit 16).

As a result of processing an average additional 300 mb/d crude in 2016 compared with 2010, the region is more self-sufficient, and PADD 2 now supplies 87% of regional demand for refined products. Most of this improvement was seen in reduced imports into PADD 2 from the Gulf Coast. Net transport fuel flows in and out of PADD 2 from the Gulf Coast (inbound flows of gasoline, jet kero, and distillate minus outbound flows) were down 27% to a monthly average 358 mb/d compared with 493 mb/d in 2010.

Overall net imports of transport fuel to PADD 2 (the balance of imports from PADD 1 and PADD 3 as well as exports to PADD 4) fell 26%, from an average 714 mb/d in 2010 to 528 mb/d in 2016.

Exhibit 16 PADD 2 Supply and Demand for Transport Fuels



Source: EIA, Morningstar

Propane

PADD 2 monthly demand for refinery propane (used in residential and commercial heating as well as agriculture) averaged 230 mb/d in 2016. This demand is highly seasonal and weather related, but it was more than met by local refinery supply, which averaged 302 mb/d in 2016. Additional propane supplies shipped into PADD 2 from the Gulf Coast as well as imported from Canada meet winter propane demand spikes. As discussed in our February note ("Propane Exports Balance Demand"), more propane is now produced from gas processing than refining.

Refined Product Exports

As noted above, PADD 2 refineries produce 87% of the transport fuels that the region consumes. Although this makes the region nearly self-sufficient, it also places a limit on local demand for refined product that in turn restricts refinery growth. As with elsewhere in the U.S., refined product transport fuel demand has been stagnant for the past several years. The Midwestern population is static at best, and more efficient autos consume less gasoline. The same is true for the Canadian Midwest. Since the oil price crash in 2014, there have been some signs of increased gasoline demand, but it is unclear if this will be sustained.

This lack of regional demand growth places a firm constraint on PADD 2 refinery expansion prospects. That is because the region is landlocked and has few efficient outlets to international markets outside Canada, besides barge shipments to the Gulf Coast on inland waterways. The lack of access to overseas markets is in clear contrast to PADD 3, where 50% of the nation's refinery capacity is located. Per EIA, in 2016, Gulf Coast refineries on average exported 672 mb/d of gasoline, 1,023 mb/d of distillates, 137

mb/d of jet kero, and 429 mb/d of pet coke. Equivalent exports (average) from PADD 2 were 18 mb/d of gasoline (3% of Gulf Coast volume), 8 mb/d distillate (1%), and less than 1 mb/d of kero. Ease of access to export markets has allowed Gulf Coast refiners to process additional crude when margins are good without concern about domestic demand. There are also other advantages that exporters can enjoy; for example, they can avoid U.S. fuel market regulations that can eat into refinery margins, such as the Renewable Fuel Standard mandates that require blending biofuels into gasoline and diesel.

Refinery Yield

EIA refinery survey data shows that PADD 2 refined product output was unchanged over the seven-year period from 2010 to 2016. The average refined product yield from a barrel of crude in 2010 was 51% gasoline, 29% diesel, 7% jet fuel, and 4% coke (the residue from a coker unit). In 2016, the yield was an almost identical 52% gasoline, 28% diesel, 7% jet, and 5% coke. Although the product yield did not change, PADD 2 refiners processed heavier crudes in 2016, meaning that they extracted higher value from less valuable crude.

Refining Margins: Crack Spread Analysis

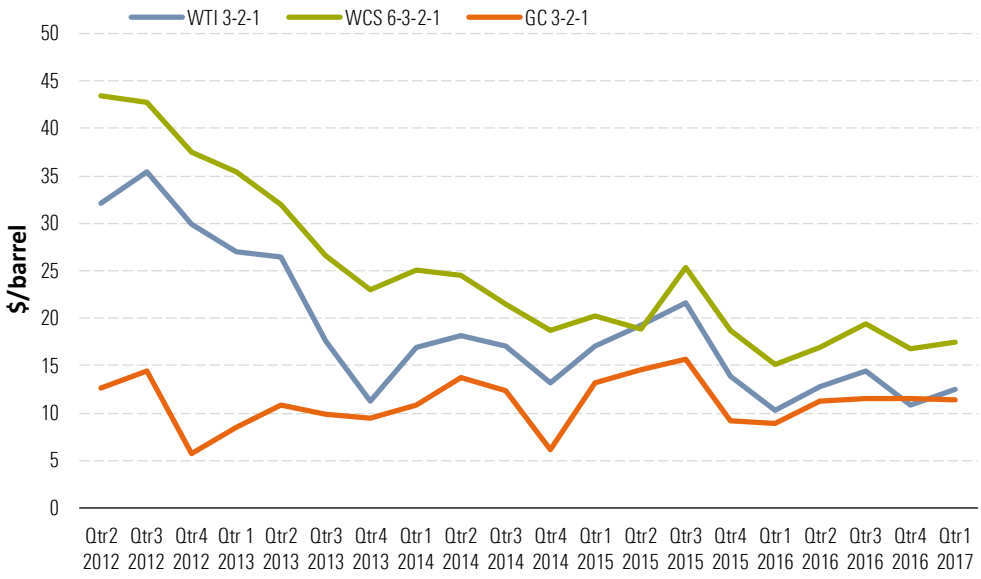
Each of the 26 refineries in PADD 2 performs differently depending on individual configuration and the crude slate processed. In the final section of this outlook, we provide detail about the configuration and crude slate of individual refineries.

The following high-level refining margin analysis, based on prices between April 2012 and March 2017, is necessarily generic, but it provides benchmark indicators of regional performance. As with our previous analysis in this series, we use crack spreads to mimic refining margins. The principal variable in PADD 2 refinery performance is whether the plant has coking capacity to process heavy crude. Feedstock costs for refineries processing heavy crude have remained lower than those for refineries processing light crude throughout the period as a result of pipeline congestion constraining Canadian heavy crude exports. However, as noted earlier, during the initial surge of shale production in 2012 and 2013, much of that crude was landlocked at Cushing, and PADD 2 refiners also benefited from significant discounts for light crude.

Light vs. Heavy Crude in Chicago

Looking first at the big picture, we compared two crack spreads: for light and heavy crude processed into refined products sold in the Chicago area. Chicago is in the largest Eastern Midwest refining district within PADD 2 and home to the most refinery coking capacity. We also compared the two Chicago crack spreads with a light crude crack at the Gulf Coast in Exhibit 17; the results are presented in the bottom half. The heavy crude crack spread is based on processing Western Canadian Select dilbit crude priced at Cushing, at a coking refinery. Each barrel of WCS produces three barrels of gasoline (Chicago price), two barrels of diesel (Chicago) and one barrel of fuel oil (New York price). The light crude Chicago crack uses West Texas Intermediate Cushing as a feedstock, producing two barrels of gasoline and one barrel of diesel sold at Chicago prices. The Gulf Coast comparison is a 3-2-1 crack spread using Light Louisiana Sweet crude priced at St. James, Louisiana, to produce two barrels of gasoline and one barrel of diesel sold at Gulf Coast prices. The results are presented as quarterly averages in Exhibit 17.

Exhibit 17 PADD 2 Crack Spread Analysis



	WTI 3-2-1	WCS 6-3-2-1	GC 3-2-1
Qtr2 2012	32.07	43.44	12.66
Qtr3 2012	35.49	42.77	14.38
Qtr4 2012	29.93	37.44	5.78
Qtr 1 2013	27.02	35.48	8.51
Qtr2 2013	26.45	32.03	10.84
Qtr3 2013	17.56	26.56	9.94
Qtr4 2013	11.23	23.06	9.51
Qtr1 2014	16.86	25.05	10.81
Qtr2 2014	18.23	24.52	13.81
Qtr3 2014	17.02	21.43	12.37
Qtr4 2014	13.17	18.72	6.12
Qtr1 2015	17.12	20.24	13.13
Qtr2 2015	19.32	18.92	14.61
Qtr3 2015	21.68	25.35	15.66
Qtr4 2015	13.86	18.77	9.24
Qtr1 2016	10.26	15.07	8.90
Qtr2 2016	12.85	16.94	11.28
Qtr3 2016	14.51	19.44	11.56
Qtr4 2016	10.92	16.72	11.51
Qtr1 2017	12.49	17.43	11.47

Source: CME Group, Morningstar

Processing heavy WCS in Chicago produced the best margin over our analysis period. This reflects cheaper prices for Canadian crude and the high yields of transportation fuels that sophisticated coking refineries produce. The width of the 6-3-2-1 crack narrowed throughout the period except for a brief recovery in the summer of 2015. The decline mirrored the unwinding of major crude congestion in the

Midwest as pipelines were built to transport more crude to market. The 6-3-2-1 crack averaged $41/barrel in 2012 (second quarter to fourth quarter), falling to $29/barrel in 2013 and $17.43/barrel through March 10, 2017.

Over same period, the light crude 3-2-1 WTI Chicago crack performed less impressively, even though margins still averaged close to $33/barrel in 2012, falling to $12.50/barrel in the first quarter of 2017. WTI margins narrowed closer to Gulf Coast levels as congestion out of the Midwest for shale crude was resolved by new pipelines and crude export restrictions were lifted, removing an artificial tax on domestic crude. The Midwest light and heavy margins are considerably higher than equivalent Gulf Coast LLS 3-2-1 yields until 2016, when the end of export regulations removed the inland crude advantage for shale barrels.

Chicago vs. Group 3

Within the Midwest, our analysis showed that on average, 3-2-1 crack spreads were higher in the northern part of the region than the south. Over the past three years from the second quarter of 2014 to the first quarter of 2017, the WTI 3-2-1 crack spread margin for refineries in the Chicago area averaged $0.70/barrel higher than the same crack for refineries in the southern Midwest, Group 3 district, reflecting higher refined product prices in the Chicago area.

The more nuanced 4-3-1 crack spread is used as a benchmark by refiner PBF for its plant in Toledo. This crack reflects three barrels of gasoline and 50/50 mix barrel of jet kerosene and diesel. Such a configuration has a higher gasoline yield than the 3-2-1 crack. The 4-3-1 crack performed worse than the 3-2-1 in Chicago by an average $0.84/barrel over the past three years, reflecting higher demand and prices for diesel than for gasoline.

Role of Cushing

It's not possible to review PADD 2 refining without noting the central role in the region of the crude oil storage and trading hub at Cushing, Oklahoma. Often dubbed the pipeline crossroads of the world, Cushing sees millions of barrels of crude entering and leaving by pipeline each day. Inbound domestic crude supplies to Cushing come from local plays in Oklahoma and Kansas as well as domestic production in North Dakota, the Rockies, and the Permian Basin. The majority of domestic inbound barrels to Cushing is light sweet crude matching specifications for the benchmark CME Nymex WTI futures contract. Futures traders that do not close out positions before their contracts expire must make or take delivery at Cushing, giving the hub an outsize influence on the world's crude stage. Aside from CME futures, nearly all domestic crude transactions are priced at some kind of differential to WTI Cushing. Significant heavy crude volumes also flow into Cushing from Western Canada and out again to regional refineries or the Gulf Coast.

Cushing is important for fundamental crude supply to the Midwest as well as the Gulf Coast, since it acts as a pivot supply point to both markets. When processing demand increases at Midwestern refineries, barrels are pulled into the region via Cushing by higher prices. Inversely, crude is pulled south from Cushing when Gulf Coast refinery margins are higher than the Midwest. The hub also provides

significant blending and storage capacity, much of which is available to refiners for staging and blending crude supplies. Cushing is particularly useful as a blending facility that has easy access to incoming heavy crude from Canada as well as light domestic sweet and sour crude from the Permian Basin and ultralight shale crude from the Bakken, Rockies, and Oklahoma STACK and SCOOP plays. These various grades can be blended in tank at Cushing into a cocktail of feedstock varieties that optimize price and performance for refiners.

Ten of the 26 refineries covered in this survey, representing 1.9 mmb/d of capacity and located in Oklahoma, Kansas, Illinois, and Indiana, are connected to Cushing by pipeline (Exhibit 18). These include the latest addition—the Hewitt Lateral to the Red River pipeline feeding Valero's Ardmore, Oklahoma, refinery—and the Plains/Valero joint venture, the Diamond pipeline, expected to be completed in the fourth quarter of 2017 and feeding Valero's Memphis plant (currently supplied from the Gulf Coast by the Capline system).

Exhibit 18 PADD 2 Refineries Connected by Pipeline to Cushing

Refinery	Owner	Capacity mb/d	Pipeline from Cushing	Capacity mb/d	Pipeline Owner	Comment
Wood River	Phillips 66/Cenovus	336	Ozark	230	Enbridge	Expands Q2 2018 to 345 mb/d
Whiting	BP	414	BP1	180	BP	
Memphis	Valero	190	Diamond	200	Plains/Valero	Starts Q4 2017
El Dorado	Holly Frontier	138	Osage	168	Holly/Magellan	
Coffeyville	CVR	115	Cushing to Bloome	110	Plains	
			Bloome to Coffeyville	170	CVR	
McPherson	CHS	86	Jayhawk via Osage	140	CHS	
El Dorado	Holly Frontier	138	Jayhawk via Osage	140	CHS	
Ponca City	Phillips 66	200	CushPo	130	Phillips 66	
Tulsa E&W	Holly Frontier	155	Cimarron South	30	Magellan	
			West Tulsa	50	Enbridge	
			Oklahoma 1 &2	70	Sunoco	
Ardmore	Valero	86	Red River Hewitt Lateral	150	Plains/Valero 60:40	Started Jan 2017
	Total	1858				

Source: Morningstar, company presentations

Cushing Storage

Because of its physical importance to the U.S. crude distribution system and its link to the benchmark futures contract, Cushing storage and the level of crude in storage have an outsize influence on crude prices. As of September 2016, the latest EIA survey showed total Cushing crude storage capacity was 77.1 million barrels (Exhibit 19). As of the March 17, 2017, weekly petroleum status report, the Cushing tanks held an estimated 68 million barrels of commercial crude (88% full). This is slightly down from the 68.3 million-barrel record inventory level reported in May 2016 but still close to record levels.

Exhibit 19 Cushing Commercial Crude Inventory

Source: EIA

Over the past seven years, changing Cushing crude inventory levels have reflected domestic crude fundamentals before, during, and after the shale boom. When shale crude production took off in 2011, supplies overwhelmed PADD 2 refinery capacity. There were no major pipeline routes from the Midwest to the Gulf Coast, leading to a buildup of inventory at Cushing. Between January 2010 and January 2013, 16 million barrels of crude were added to Cushing, increasing inventory by 44% to 52 million barrels. Inventory levels fell rapidly after May 2013, reaching a low of 18 million barrels in July 2014, as the first two phases of the Enterprise/Enbridge Seaway pipeline came on line, opening up capacity between Cushing and the Gulf Coast. Since the low of July 2014, Cushing inventories have filled to record levels in response to the crude price crash. World crude prices were driven down by oversupply, causing a contango structure in the futures market (see our May 2016 note "Heating Oil Contango" for more on contango) with prices for future delivery higher than today. In a contango market, traders and speculators use storage to profit from higher prices in the future by putting physical crude in storage. Because of its status as the delivery point for CME Nymex WTI futures, using Cushing storage makes the

contango play particularly efficient, encouraging an increase in inventory levels. Continued market oversupply has kept Cushing inventory levels high this year.

Close market attention to Cushing inventory levels as a barometer of U.S. crude supply often results in speculative storage by traders, which can distort market prices for refiners. Generally, refiners benefit from higher inventory levels that place downward pressure on current prices in a contango market. Refiners need to pay more attention to purchase timing when crude prices in the future are falling—the opposite of contango, known as backwardation.

Refinery Detail Notes

This section provides summaries of the 26 refineries in PADD 2 and their configuration and feedstock sources, based on company presentations and industry publications. Exhibit 20 lists the refiners in order of capacity.

Exhibit 20 PADD 2 Refiners by Capacity

Owner	Capacity b/d
Marathon	729,000
BP	413,500
P 66/Cenovus JV	336,000
Holly Frontier	293,300
Flint Hills Resources	290,000
Valero	276,000
ExxonMobil	239,000
Phillips 66	200,000
CVR	185,000
Tesoro	182,400
PDVSA	175,940
PBF Energy	160,000
BP/Husky JV	153,000
Husky	152,000
CHS	86,000
Calumet	38,000
Country Mark	27,100
Continental	5,500
Total	3,941,740

Source: EIA

Marathon

Marathon Petroleum is the third-largest U.S. independent refiner behind Phillips 66 and Valero, with 1.8 mmb/d of capacity at seven refineries in PADDs 2 and 3. The company has four plants representing 40% of its capacity, or 0.73 mmb/d, in the Eastern Midwest district of PADD 2 (Exhibit 21).

Exhibit 21 Marathon Refineries

Name	State	Owner	Capacity b/d
Catlettsburg	KY	Marathon	273,000
Robinson	IL	Marathon	231,000
Detroit	MI	Marathon	132,000
Canton	OH	Marathon	93,000
		Total	729,000

Source: EIA,

An integrated network of crude pipelines connects Marathon's Midwestern refineries with supplies from Canada and the Bakken as well as light condensate crude produced in the liquids window of the Utica Basin in eastern Ohio. Marathon has invested heavily to become the largest player in gas liquids processing and distribution in the Utica and Marcellus after its logistics subsidiary, MPLX, purchased MarkWest Energy in December 2015. MPLX supplies Marathon and other Midwestern refineries with condensate and natural gasoline (a similar refinery blend stock component extracted from liquids-rich natural gas) via the Cornerstone pipeline, completed in 2016. Cornerstone connects MarkWest gas processing facilities in Ohio to the Canton refinery and from there via the Marathon crude pipeline network to Husky's refinery in Lima, Ohio, as well as BP/Husky and PBF refineries in Toledo and Marathon's refinery in Detroit. In 2015, Marathon added a 25 mb/d condensate splitter to its Canton refinery and a similar 35 mb/d unit to its Catlettsburg refinery.

The Canton refinery processes light sweet, light sour, and condensate crudes supplied from the Utica as just detailed and from the company's distribution terminal at Patoka, Illinois. Crude is supplied to Patoka from Cushing via Wood River as well as from the Gulf Coast via Capline. Recent southern and eastern expansions to the Enbridge Lakehead system now make Canadian and Bakken crude available to Patoka. Marathon abandoned its stake in the proposed Enbridge Sandpiper pipeline to purchase a stake in the rival Dakota Access pipeline, which will shortly deliver up to 470 mb/d of Bakken crude to Patoka.

The Catlettsburg refinery processes light sweet and sour crude. The refinery is primarily supplied by pipeline from Patoka and the Mid-Valley system via Lebanon, Kentucky. The 35 mb/d Catlettsburg condensate splitter is supplied by inland barge from Wellsville on the Ohio River.

The Robinson refinery has a coking unit and primarily processes heavy Canadian crude delivered via Patoka. Marathon added 19 mb/d of light crude processing capacity at Robinson in 2016 that will take advantage of shale crude delivered from the Bakken on the Dakota Access pipeline.

The Detroit refinery also processes heavy Canadian crude delivered via the Line 79 lateral to Enbridge's Line 6B (Griffith to Stockbridge) and then via the Wolverine pipeline to Detroit. Crude is also delivered to Detroit via Lima from the Permian, the Gulf Coast, and Canada on the Sunoco Logistics Maumee pipeline that connects to Patoka and the Mid-Valley system.

The overall refining slate of Marathon's Midwestern refineries is 61% sour and 39% sweet crude, according to the company. The company has increased investment in light processing to take advantage of regional shale crude opportunities and is considering building a gasoline blending component plant in the Utica to produce alkylate from gas liquids.

The company's overall strategy has been to integrate refining, logistics, and refined product sales via its Speedway retail network, which includes East Coast gas stations acquired from Hess. However, this strategy—including the MarkWest acquisition—has been called into question by activist shareholder Elliott Management, which has demanded divestment of noncore refining assets.

BP Whiting

BP owns and operates the largest refinery in PADD 2: the 414 mb/d Whiting, Indiana, plant, southeast of downtown Chicago. In 2013, the company completed a $4.2 billion expansion and upgrade of the refinery, including the addition of significant coking capacity. The revamp allows the refinery to process up to 85% heavy Canadian crude, which is now supplied via the Enbridge system Line 6A from Superior, Wisconsin. BP is also supplied by the 180 mb/d North pipeline, direct from Cushing to Whiting, that is now underutilized since the majority of supply comes from Canada. BP is installing a new hydrotreating unit at Whiting, expected on line in 2017, which will reduce gasoline sulfur content to meet EPA Tier 3 gasoline regulations.

BP/Husky Toledo

BP also owns a 50% stake in and operates the 153 mb/d Toledo refinery, a joint venture with Canadian producer Husky, based around the processing of crude from the two companies' Sunrise Canadian oil sands production plant, which came on line in 2015, producing an initial 60 mb/d and eventually growing to 200 mb/d. The Toledo refinery currently processes 135-145 mb/d of heavy crude. An upgrade completed in 2016 allowed the refinery to handle an additional 35 mb/d of heavy crude with high acid content (high TAN), which is typically cheaper than other heavy crudes because it is more difficult to process. A separate project to increase heavy crude processing capacity by 40 mb/d is set to get underway in 2017. Crude is supplied to the Toledo refinery by pipeline from the Enbridge system via Line 6B and Line 17 as well as from Patoka via Lima.

Phillips 66

Phillips 66 is the second-largest U.S. independent refiner behind Valero, with 10 refineries in the U.S. (capacity 1.8 mmb/d) and three in Europe. The company also owns a U.S. logistics subsidiary, PSX Partners, which operates U.S. crude and product supply assets.

Ponca City

The 200 mb/d Phillips 66 refinery in Ponca City, Oklahoma, located 62 miles from Cushing, processes a mixture of light, medium, and heavy crude and has coking capacity. The refinery is supplied with Canadian and domestic crude from Cushing via the 130 mb/d CushPo pipeline. The 230 mb/d Pony Express pipeline, which came on line in 2015, also supplies Ponca City with shale crude from the Rockies and the Bakken (via Guernsey, Wyoming) as well as Canadian crude via the Spectra Express pipeline. The 100 mb/d Oklahoma Mainline pipeline from Wichita Falls, Texas, to Ponca supplies midcontinent and Permian Basin crude. Phillips own 700 thousand barrels of storage at Cushing.

Wood River Phillips/Cenovus Joint Venture

The 336 mb/d Wood River refinery, located northeast of St. Louis on the Mississippi River in Roxana, Illinois, is a 50/50 joint venture between Phillips and Canadian oil sands producer Cenovus, known as WRB Refining. The joint venture is similar to the BP/Husky refinery where a Canadian producer secures a buyer for its crude by investing downstream. In this case, Phillips and Cenovus jointly own Wood River as well as the 144 mb/d Borger refinery in Texas. The Wood River refinery underwent a significant upgrade in the past 10 years and can now process up to 238 mb/d of heavy crude.

Wood River has access to multiple sources of crude. These include the 230 mb/d Enbridge Ozark pipeline from Cushing to Wood River, the Spectra Express-Platte pipeline from Western Canada via Wyoming to Wood River, and the Woodpat pipeline from Patoka (supplied with crude from Canada and the Gulf Coast). Phillips 66 is a part owner of the Dakota Access pipeline connecting North Dakota and Patoka. Cenovus also has a rail terminal in Edmonton (Bruderheim), which gives it flexibility to deliver crude by rail to the WRB refineries in case of pipeline congestion.

HollyFrontier

HollyFrontier is the sixth-largest U.S. independent refiner, with five plants having 467 mb/d capacity. The company has two refinery operations in PADD 2: the 155 mb/d Tulsa, Oklahoma, plant and the 138 mb/d El Dorado, Kansas, plant. Both refineries process domestic and Canadian crude and are well connected to Cushing.

Tulsa

The 155 mb/d Tulsa refinery is located just 50 miles from Cushing and is made up of two separate facilities operated as an integrated refinery: the East and West plants. The refinery processes light and heavy crudes and has a heavy crude coker. Crude is supplied from Cushing via several pipelines—the 30 mb/d Magellan Cimarron South, the 50 mb/d Enbridge West Tulsa, and the 35 mb/d each Sunoco Logistics Oklahoma 1 and Oklahoma 2 pipelines. The West Tulsa refinery also produces specialty lubricants.

El Dorado

The 138 mb/d El Dorado refinery processes a mix of heavy and light crudes and has coking capacity. The refinery currently receives crude supplies from Cushing via the 168 mb/d Enbridge Osage system and the 140 mb/d Jayhawk pipeline. HollyFrontier signed an agreement in February with Tallgrass to build a 100

mb/d lateral between the latter's Pony Express pipeline and El Dorado that will be completed as soon as the end of 2017. The pipeline will give El Dorado access to shale crude from the Rockies and North Dakota as well as Canadian supplies.

Flint Hills Resources

Flint Hills Resources is the refining subsidiary of privately held Koch Industries. The company owns two refineries: the 290 mb/d Pine Bend refinery in St. Paul, Minnesota, and a 296 mb/d plant in Corpus Christi, Texas.

Pine Bend

The 290 mb/d Pine Bend refinery in Rosemount, Minnesota, supplies about half of Minnesota's gasoline and about 40% of Wisconsin's. The refinery processes a mix of heavy Canadian and light Bakken crude and has coking capacity. Crude supplies are primarily delivered by pipeline from Clearbrook, Minnesota, on the 465 mb/d Minnesota pipeline system. The Minnesota pipeline is connected to the Enbridge Mainline at Clearbrook and delivers both Canadian and Bakken crude supplies to Pine Bend. The refinery is also supplied via the Koch Wood River pipeline from Wood River to Pine Bend. In 2013, Koch floated a proposal for a Dakota Express pipeline (predating Dakota Access) that would reverse the Wood River pipeline and flow Bakken crude to Patoka, but the latter never received sufficient shipper support to move forward.

Flint Hills recently completed an overhaul of the refinery's coking capacity and is starting a three-year project to improve efficiency and reduce emissions in 2017.

Valero

Valero is the largest independent refiner in the U.S. with 2.2. mmb/d of capacity at 12 plants. The company has two refineries in PADD 2 with a combined 276 mb/d capacity: a 190 mb/d plant in Memphis, Tennessee, and an 86 mb/d plant in Ardmore, Oklahoma.

Memphis

The 190 mb/d Valero Memphis refinery processes light domestic crude. The refinery is supplied via the Collierville lateral to the 1.2 mmb/d Capline pipeline that runs from St. James, Louisiana, to Patoka. Before shale crude, Valero ran the Memphis plant on a diet of Light Louisiana Sweet grade crude delivered from St. James. During the period when Midwestern crude was constrained by congestion at Cushing, Valero shipped Bakken crude to St. James by rail for delivery to Memphis on Capline, which is no longer cost-effective. In 2014, Plains announced a proposed 200 mb/d Diamond pipeline project to run from Cushing to Memphis that has since become a 50/50 Valero/Plains joint venture. The pipeline is expected on line by the end of 2017.

Ardmore

The 88 mb/d Ardmore refinery is close to the Red River in Ardmore. Valero acquired the refinery as part of its Diamond Shamrock purchase in 2002. The refinery processes light and medium sour crude delivered from a regional gathering system as well as via the Plains Red River pipeline from Cushing.

Valero's logistics subsidiary, Valero Energy Partners, owns a 40% stake in the newly completed Hewitt segment of the Red River pipeline, which provides Valero Ardmore with 60 mb/d delivery capacity.

ExxonMobil Joliet

ExxonMobil owns five U.S. refineries with combined capacity of 1.7 mmb/d. The 239 mb/d Joliet refinery in Illinois primarily processes heavy Canadian crude. The refinery is supplied via the Enbridge pipeline system. ExxonMobil owns the heavy crude oil sands Kearl River project, Phase 1 of which is now producing 110 mb/d.

The company owns a crude-by-rail loading terminal in Edmonton, Alberta, which is operated by Kinder Morgan. It can deliver Kearl dilbit crude to the 85 mb/d Joliet Bulk Barge and Rail terminal, operated by CenterPoint Properties (owned by Arc Logistics 60% and GE Energy Financial Services 40%). The terminal is connected to Joliet by a four-mile-long 200 mb/d pipeline. The rail unload terminal is equipped with steam heat facilities to unload heavy crude that is too viscous for pipeline shipment. The Joliet rail terminal provides ExxonMobil with insurance against pipeline congestion out of Western Canada. Using railcars to transport crude means the company can also economize on crude diluent costs, since the heavy bitumen can be transported in rail cars with less solvent.

Coffeyville Resources (CVR)

CVR is a small independent refiner with two refineries in the Group 3 district close to Cushing. The company is majority owned by investor Carl Icahn. The 115 mb/d Coffeyville, Kansas, refinery processes heavy crude and the 70 mb/d Wynnewood, Oklahoma, refinery processes light crude. Subsidiary Coffeyville Resources Crude Transportation operates a 65 mb/d crude gathering operation that purchases crude from independent producers in Oklahoma, Kansas, Nebraska, Missouri, and Texas. CVR also own 1.5 million barrels of Cushing storage capacity.

Coffeyville Refinery

The Coffeyville refinery is located north of Cushing and runs a slate of medium and heavy sour crude, mostly Canadian grades delivered via Cushing. The plant has coking capacity and is connected to Cushing by the 110 mb/d Plains Cushing to Broome pipeline that ends at a CVR terminal in Broome, Kansas. The terminal also receives inbound crude by truck from regional gathering systems. CVR has an 80 mb/d take-or-pay term shipping commitment on the Plains pipeline. A larger 170 mb/d CVR-owned pipeline connects Broome to the Coffeyville refinery.

Wynnewood

The Wynnewood refinery is fed primarily from CVR's gathering system and processes light crude. In September 2016, CVR entered into an agreement to invest in a 40% stake in the Velocity Central Oklahoma pipeline, a joint venture with Velocity Midstream Partners. The partners will construct a terminal and pipeline linking the Wynnewood refinery to the South Central Oklahoma Oil Province (SCOOP) shale oil play. The new pipeline will provide Wynnewood access to an initial 45 mb/d of light sweet and condensate crude expected on line in April, expandable to a maximum capacity of 120 mb/d.

Tesoro

Tesoro is the fourth-largest U.S. independent refiner with 1.3 mmb/d of capacity. Following its November 2016 acquisition of Western Refining, Tesoro now operate 13 refineries in the Western and Southwestern U.S. as well as three plants in PADD 2, located in North Dakota and Minnesota.

Mandan and Dakota Prairie

The 74 mb/d Mandan and 19.5 mb/d Dakota Prairie refineries in North Dakota process light sweet crude and sit atop the abundant Bakken Shale, giving them advantaged access to unlimited crude supplies since there are only two refineries in the state and the majority of production is shipped out by rail or pipeline. Tesoro expanded the Mandan plant in 2013 to process an additional 18 mb/d of the local light sweet crude. The company acquired the smaller brand-new Dakota Prairie refinery from Calumet in 2016 after the plant failed to break even during its first year of operation. By integrating the smaller plant's operation with the larger Tesoro network (and buying it for a fire-sale price), Tesoro should be able to run the smaller plant more profitably. Crude is supplied to both plants by local gathering systems.

St. Paul Park

Tesoro acquired the 89 mb/d St. Paul Park refinery in the Twin Cities last November as part of the Western Refining deal. Western only owned the refinery for six months, having acquired it through the merger with Northern Tier in June 2016. The refinery processes light and medium crude and has no coking capacity.

Crude supply for the St. Paul Park refinery comes exclusively via the 465 mb/d Minnesota pipeline system that connects the Twin Cities to Clearbrook. Clearbrook is a strategic junction on the Enbridge system where the mainline from Western Canada is joined by the Enbridge North Dakota pipeline. Tesoro can therefore supply this refinery with a mixture of Canadian light and heavy crude as well as Bakken shale.

PDVSA Citgo Lemont

The 176 mb/d Citgo Lemont refinery is located southwest of Chicago. The refinery processes heavy crude. Despite Citgo parent Venezuelan national oil company PDVSA being one of the world's biggest producers of heavy crude, the Lemont refinery processes crude from Canada, which makes sense, given the expense of delivering imported crude to Chicago as well as the prevailing discounts for Canadian barrels.

The refinery receives crude from two pipeline systems. The Enbridge Mainline delivers into the Chicago area from Superior, Wisconsin, via Line 6A. The Chicap pipeline between Patoka and Chicago delivers crude from Patoka. The Patoka crude hub receives a mixture of supplies from Canada, the Bakken, and the Gulf Coast via the Capline system.

PBF Toledo

PBF Energy is the fifth-largest U.S. independent refiner that now owns four refineries on the East, Gulf and West coasts as well as the Toledo plant in the Midwest. PBF's total refining capacity is 467 mb/d.

The Toledo refinery processes light crude and has no coking capacity. According to the company's IPO prospectus, the refinery runs a mixture of Bakken shale crude and Canadian synthetic (light) crude.

Crude supply for the PBF Toledo plant comes from two directions. From the south, the Sunoco Maumee pipeline delivers crude from the Permian Basin (via Mid-Valley) and Patoka. From the north, Canadian and Bakken crude are delivered on the Enbridge system east of Chicago via Line 6B and Line 17.

Husky Lima

Toronto-headquartered Husky Energy is an international oil and gas producer with significant interests in Canadian oil sands crude production. The company owns one refinery in Toledo as a joint venture with BP and owns the 152 mb/d Lima refinery outright. The Lima refinery can process both light and heavy crude and has coking capacity. A project is underway to expand heavy crude coking capacity to 40 mb/d by 2019. The refinery currently processes 60 mb/d of synthetic crude from the company's Lloydminster, Alberta, heavy oil upgrader facility and around 90 mb/d of purchased light crude. The Lima refinery receives crude supplies from Patoka and the Mid-Valley system.

CHS McPherson

CHS (formerly Cenex Harvest States) is a leading global agribusiness owned by farmers, ranchers, and cooperatives across the U.S. The company is a cooperative that returns its profits to members, primarily farmers. CHS own two refineries in the U.S.: a 60 mb/d plant in Laurel, Montana (PADD 4), and an 86 mb/d plant at McPherson, Kansas, in PADD 2.

The 86 mb/d McPherson refinery is currently being expanded to 97 mb/d (2017). According to Securities and Exchange Commission filings, the refinery processes approximately 75% light and medium crude oil and approximately 25% heavy crude oil and has coking capacity. Light and medium crude oil is sourced from gathering systems in Kansas, North Dakota, Oklahoma, and Texas. Heavy crude comes from Canada via the Jayhawk and Osage pipeline systems, which connect to Cushing. CHS distributes refined products through its Midwestern retail Cenex network.

Calumet Superior

Calumet Specialty Products Partners is a niche fuel product refiner with four U.S. refineries in Texas, Louisiana, Montana, and Wisconsin. The company also manufactures specialty chemical and lubricant products and provides oilfield services and liquids storage. The 38 mb/d Calumet refinery in Superior, Wisconsin, processes a mix of light and heavy crude supplied from the Bakken and Canada (a mix of light synthetic, mixed sweet blend crude, and heavy crude). The refinery has no coking capacity.
The Calumet refinery is located close to the Enbridge Mainline Superior terminal, providing easy access to Canadian and Bakken supplies.

According to a March 16 report by Reuters, Calumet is looking to sell the plant and has retained Tudor, Pickering, Holt to advise it in the transaction. The company is trying to diversify away from refining because margins are lower than in its core specialty chemical business.

CountryMark

The 27 mb/d CountryMark refinery in Mount Vernon, Indiana, is owned and operated by CountryMark Cooperative Holding—another co-op, but smaller than CHS. This baby refinery processes light crude gathered from local Illinois Basin producers. The refinery provides fuel for members as well as nonmembers through retail outlets.

Continental

The small, privately held 5.5 mb/d Continental refinery in southern Kentucky dates back to the 1940s. The Haseotes family, which also owns Cumberland Farms, the Gulf Oil gas station chain, and the Hemisphere Management truck stop company, currently owns the refinery. The refinery is a simple distillation plant that runs light sweet crude purchased from local producers and delivered by truck.

Proposed New Refinery by Meridian Energy

Meridian Energy's proposed 55 mb/d Davis refinery, to be located near Belfield, North Dakota, would be the second new refinery in North Dakota designed to process local Bakken shale crude, after the Dakota Prairie plant completed in 2015. Phase 1 of the plant will process up to 27.5 mb/d and was originally expected to be up and running by the end of 2017. The plan calls for crude oil to initially be delivered to Davis by rail, with potential for a future pipeline connected to local gathering systems.

The planned configuration and crude processing of the refinery has evolved as the refinery awaits permitting to begin construction. According to the North Dakota Department of Health, the air quality permit review process could take 9-12 months, meaning that the permit will not be available to start construction until October.

If built, the first phase of this refinery will face the same market headwinds experienced by the Dakota Prairie plant, which was sold to Tesoro at a loss after one year. The challenge is to find profitable markets for refined products in North Dakota without benefit of an existing distribution system. Earlier presentations by Meridian suggested the plant might be run as a tolling arrangement where producers provide crude in return for refined product output, leaving the owner to profit from processing fees. This does not appear to have secured sufficient support from producers.

Winners and Losers

Heavy Crude Advantage

Per our crack spread analysis above, the clear refinery winners in PADD 2 over the past six years are those with heavy crude coking capacity and access to Canadian crude supplies. The advantage these refiners possessed has largely been attributable to tight pipeline capacity for Canadian crude exports during a period when increasing oil sands production has added to the congestion and kept prices low.

While this heavy crude advantage has proved profitable to Midwestern refiners with coking capacity, they cannot rely on this situation continuing indefinitely. Canadian heavy crude production is likely to continue to expand until 2020 because of new oil sands projects already invested that are expected on line. After then, production is likely to decline if there is no investment in new projects (see "Lower For

Longer"). By 2020, Canadian producers may also have new pipeline capacity to ease congestion, including access to the West Coast on the expanded Kinder Morgan Trans Mountain pipeline and possible completion of the Keystone XL pipeline, which has been approved by the Trump administration. These developments would increase demand for Canadian crude and expose PADD 2 refiners to a possible bidding war to secure supplies. Such a development would penalize PADD 2 refiners that do not have secure supply agreements. In these circumstances, the likely winners would be producers Husky and Cenovus, which have invested in refinery capacity and own crude, as well as ExxonMobil, BP, and Phillips 66, which have equity interests in Canadian production.

Light Crude Advantage

Our analysis showed that PADD 2 refiners with light or medium crude processing configurations did well during the initial shale surge but that their advantaged margins have narrowed to the same level as Gulf Coast refiners in 2017. Prospects for these refineries will improve if shale production surges again and producers have to compete for buyers. This is less likely now that exports are not restricted, because the base market price for shale crude will be set in the international market.

Marathon has invested intelligently in its PADD 2 refineries to take advantage of access to condensate that would otherwise be stranded a long way from market. It should continue to benefit as long as production does not decline in the face of lower prices.

Landlocked

Overall, the biggest constraint on PADD 2 refiners improving their performance is the lack of new demand. Even as heavy crude processors are still enjoying relatively high margins, they are hard-pressed to increase processing capacity because of the danger of flooding the market with unwanted product that will squeeze margins. This constraint in the Midwest is in contrast with Gulf Coast refiners, which have easy access to a growing refined product export market.

New Refineries

The failure of the Dakota Prairie refinery sold to Tesoro after one year of operation shows how risky startup refineries can be. However attractive advantaged crude access looks, the challenge remains finding a market for the refined product output without an existing network. We believe this challenge will also dog the proposed 55 mb/d Davis refinery in North Dakota. The owners of that project have to find a new source of demand for the output before it can be successful.

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