Refiners' Slow Response to the Octane Challenge

Octane premium is widening in the face of growing demand.

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U.S. Energy Information Administration
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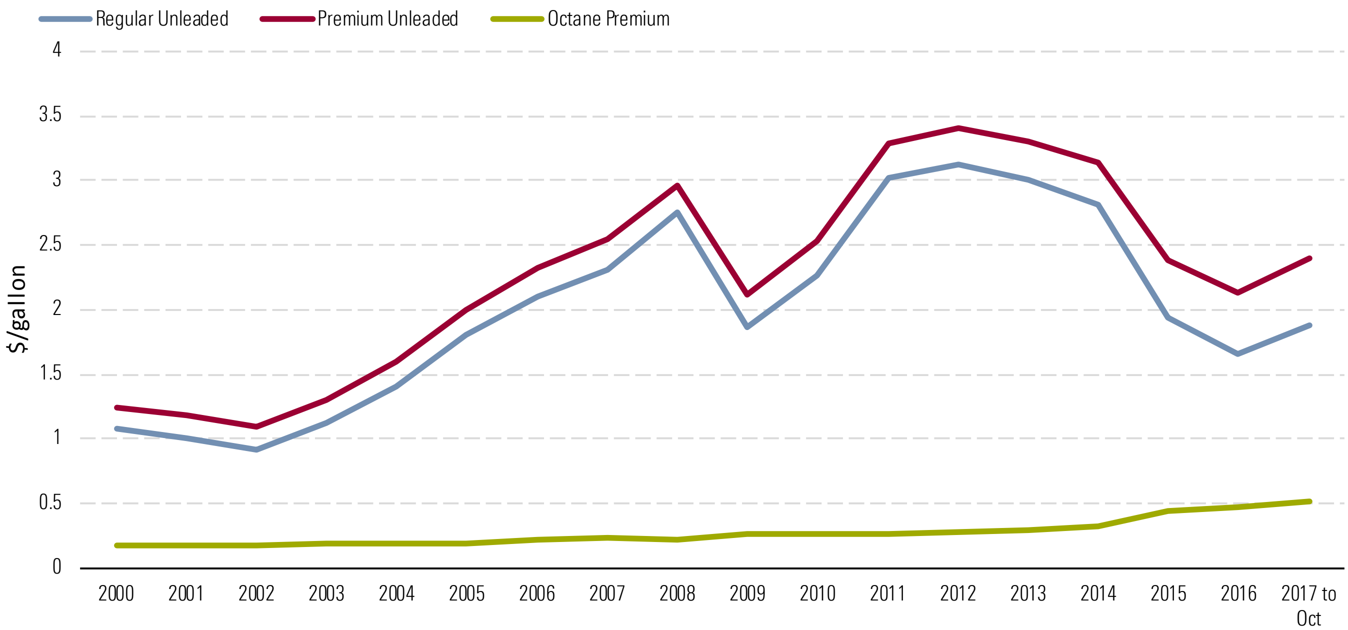
Turbocharged Premium Demand

Largely because of tightening corporate average fuel economy standards enacted by Congress in 1975 to reduce fossil fuel consumption and regulated by the Department of Transportation, annual average premium gasoline sales as a percentage of overall gasoline supplied to the U.S. market have increased by 10%, or 120 thousand barrels a day, since 2010. That trend is expected to continue. Improved fuel efficiency to meet CAFE standards is best achieved by higher engine compression ratios, and auto manufacturers favor using turbochargers to accomplish this. However, turbos raise the risk of fuel combustion before sparkplug ignition, or engine knock—a condition that is mitigated by increasing the octane content of gasoline. Manufacturers of turbocharged vehicles therefore require the use of premium gasoline, which has a higher octane rating than regular gasoline. A delayed reaction to this requirement from U.S. refiners as well as a complex series of trade-offs in gasoline blending has caused octane premiums (the price difference between premium and regular gasoline) to almost double from an average $0.27/gallon in 2010 to an average $0.51/gallon between January and October 2017. This note looks at refiners' options to address growing octane demand and the consequences of inaction.

Octane Premium

For those driving luxury autos, the widening difference at the pump between premium and regular gasoline is perhaps considered a small price to pay for the privilege of sporting a marquee badge on the hood. But the population of premium gas buyers is growing faster than the stable of luxury cars. As of 2016, about 20% of all new vehicles came equipped with a turbocharger, and the Energy Information Administration projects that share to increase to over 80% of new vehicles by 2025. Increased demand for premium gasoline has widened price differentials at the pump in the past few years. Exhibit 1 shows EIA annual average retail prices (excluding taxes) paid to refiners for regular and premium gasoline since 2000 as well as the price differential between premium and regular, known as the octane premium. The average octane premium remained steady at $0.17-$0.27/gallon between 2000 and 2011 but has nearly doubled since then to an average $0.51/gallon between January and October 2017. The higher premium reflects rising octane costs and tighter supplies.

Exhibit 1 Octane Premium



Source: EIA, Morningstar

Gasoline Blending

Two different methods—the research octane number and the motor octane number—are used to rate the octane content of gasoline, a measure of its performance when compressed. U.S. gas pumps display an average of these two: (R+M)/2. Regular gasoline is defined as 87 (R+M)/2, and premium gasoline is 91 to 93 (R+M)/2. As we detailed in a March 2017 note ("Gasoline Prices Spring Higher as Trump Ponders Deregulation"), gasoline is a complex mix of components blended to meet a variety of regulatory requirements that differ throughout the country. Octane is just one measure that refiners need to juggle with others dictated by federal regulations, such as Reid vapor pressure, which varies by season and geographic region, and levels of sulfur and benzene. Refineries use complex linear programs to optimize gasoline blending of components output from primary distillation, downstream catalytic cracking, and coking or processes such as naphtha reforming and alkylation. External blending components include corn ethanol added at the distribution terminal to meet renewable fuel standards.

Octane Components

The principal components used to boost octane are reformate, alkylate, ethanol, and butane, each of which has its pros and cons.

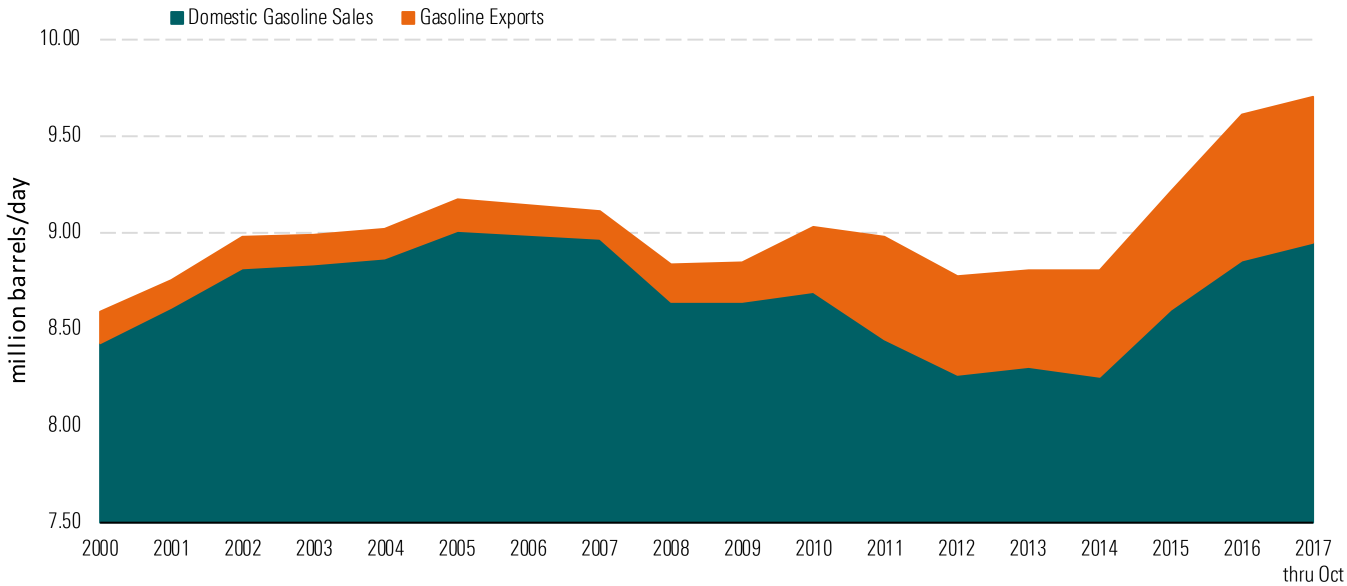
- *Reformate.* Refinery catalytic reformer units convert naphtha feedstock into high-octane, high-aromatic reformate with byproducts including hydrogen. Octane content is increased at higher temperatures and with greater catalyst consumption, but costs rise accordingly. Heavy naphtha (containing more aromatic components such as benzene, toluene, and xylene) produces higher octane reformate. Surging U.S. shale crude production typically produces lighter naphtha components that are less suited to reforming.

- *Alkylate.* Alkylation units produce alkylate from isobutane and butylene components typically produced as byproducts of catalytic cracking. Alkylation uses sulfuric or hydrofluoric acid as a catalyst to produce alkylate, an isoparaffin that has high octane and low sulfur and RVP levels. Alkylation units are expensive to build, and their use of acid makes them difficult to obtain permits for. In California, the South Coast Air Quality Management District board has sought to ban alkylation because of the risk of an acid cloud. Chevron is installing an alkylation unit at its Salt Lake City refinery using a new Isoalky technology with a less volatile ionic liquid catalyst, which could make adding alkylation capacity easier if it is successful.
- *Ethanol.* Made from corn in the United States, ethanol has a high octane rating of 113 (R+M)/2, making it an attractive gasoline blending component. Ten percent ethanol is already blended into most U.S. gasoline to meet renewable fuel standard mandates. Adding more ethanol to gasoline blends is often the lowest-cost solution to boost octane. However, ethanol has a relatively high RVP level, and auto and logistics constraints have practically limited its blending to 10% of gasoline by volume so far. Refiners dislike ethanol because they don't produce it themselves, so it is swallowing their market share. If they do not blend ethanol into gasoline themselves, they have to purchase renewable credits called RINs to comply with the RFS mandates. Perceived RIN shortages have increased independent refiners' costs significantly in the past few years (see our September 2016 note, "Corn Crush and RINS—Tighter Margins For Producing and Blending Ethanol").
- *Butane.* A gas liquid byproduct from refining or gas processing, butane is blended into gasoline to boost octane during the winter. However, it has a very high RVP level and is therefore not practical to use in the summer when higher temperatures increase evaporation.

Gasoline Production

As refiners have wrestled with different options to increase octane over the past four years, they've added to the challenge by producing ever higher volumes of gasoline (Exhibit 2). According to EIA, gasoline output dipped between 2006 and 2012 in response to increased ethanol blending under RFS mandates and lower demand following the Great Recession. But since 2012, output has increased by over 1 million barrels/day to average nearly 10 mmb/d in 2016 and 9.9 mmb/d between January and October 2017 (reduced by the impact of Hurricane Harvey). While domestic gasoline demand has increased—particularly since the oil price crash lowered pump prices—much of the growth in output has been destined for a booming export market (see our November 2016 note "Sailing Around The Wall? U.S. Refined Product Exports to Mexico"). Although exports are typically regular-grade gasoline, the combination of increased output and higher domestic demand for premium grades adds to the overall octane demand crunch.

Exhibit 2 U.S. Gasoline Sales



Source: EIA, Morningstar

Slow Response

Despite rising octane demand and attractive octane premiums, U.S. refiners have been slow to respond with investment in new capacity. Annual EIA refinery capacity reports indicate that while overall crude processing capacity increased by 14% to 19.8 mmb/d since 2000, alkylation capacity only increased 10% over the same period. And although refiners increased low-pressure reformer technology (versus high-pressure) from 59% of capacity in 2000 to 71% in 2016, overall reformer capacity remained static over the period. However, a number of alkylation or related projects have been proposed in the past two years, some of which are now being completed. These include a new 13 mb/d alkylation unit at Valero's Houston refinery set for completion in 2019 and Marathon's upgrade to the fluid catalytic cracking and alkylation units at its 539 mb/d Garyville, Louisiana, plant (started in 2016) and a similar upgrade proposed for its 132 mb/d Detroit plant. On Jan. 9, Delek announced it is building a 6 mb/d alkylation unit at its 74 mb/d Krotz Springs, Louisiana, refinery that is scheduled for completion in 2019. Also, many eyes are on Chevron's Salt Lake City Isoalky prototype unit, which could ease permitting issues if successful. A notable exception to recent investment decisions is the 2015 Marathon proposal for subsidiary MarkWest to build a stand-alone alkylation unit in Ohio to upgrade abundant cheap gas liquids from the Appalachia basin into alkylate. This project is still being evaluated but has disappeared from company presentations.

Import Alternative

One alternative for U.S. refiners is to import octane blending components, but EIA data show this is not happening outside the East Coast region. Blending component imports to East Coast refineries represented a monthly average 86% of the U.S. total between January and October 2017. That's because the East Coast is a net importer of refined product since local refineries only produce about 30% of regional demand (see our July 2017 note "East Coast Refineries Recover From Shale Loss"). Other regions import only a fraction of their blending component needs, suggesting that overseas supplies are too scarce or expensive to be a viable alternative to homegrown components.

Refiner's Challenge

The challenge for U.S. refiners is that slow investment in new octane capacity encourages alternative solutions. For example, increasing ethanol blends above 10% could become a practical necessity to solve the octane gap but would reduce oil refiners' share of the gasoline market and potentially increase the pain of RIN payments. In the longer term, delays in U.S. refinery investment are likely to become embroiled in concerns about peak demand for transport fuels. With a lot of attention being paid to electric vehicles, refiners may find it harder to justify investment in new gasoline production facilities in the next decade. Given the octane premium available today and CAFE standards that underwrite higher demand, we believe it makes more sense to invest in new capacity now than to stand idly by and watch alternative solutions grab market share.

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