



Clean fuels and the FCC

George Hoekstra
RefComm Galveston 2022
May 11, 2022



Hoekstra Trading LLC

Seven years ago, I was in a meeting with a refiner who was very interested in Tier 3 gasoline. We started a research project to address some weak links in Tier 3 technology. The project included pilot plant testing and commercial field testing on gasoline desulfurization to meet the Tier 3 10 ppm gasoline sulfur specification. Today I am still talking about clean fuels and the FCC, and my topic is still Tier 3 gasoline.



Tier 3 gasoline – A wolf in sheep's clothing?

Clean fuels and the FCC

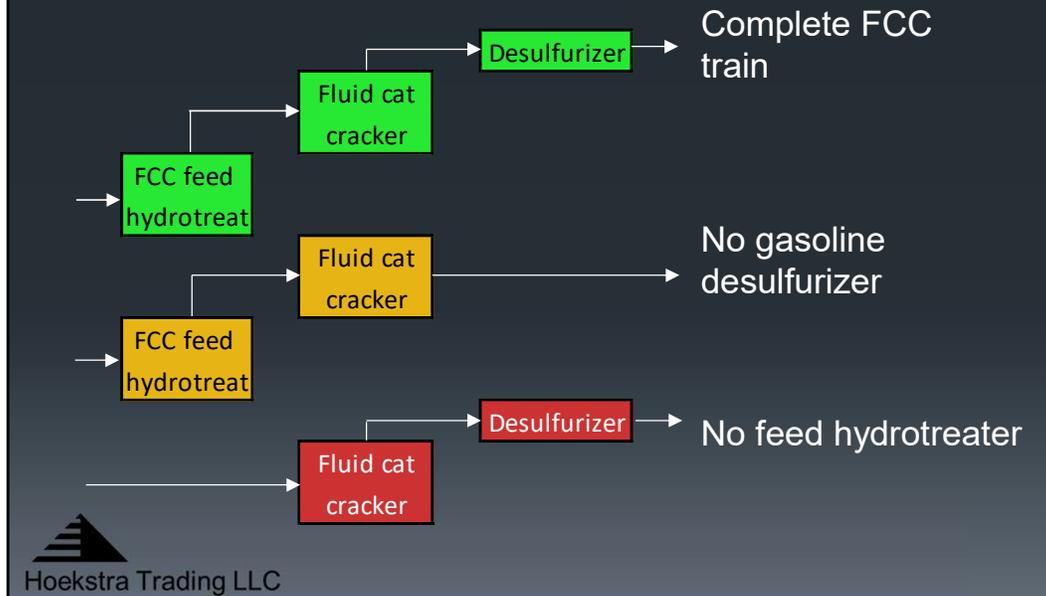
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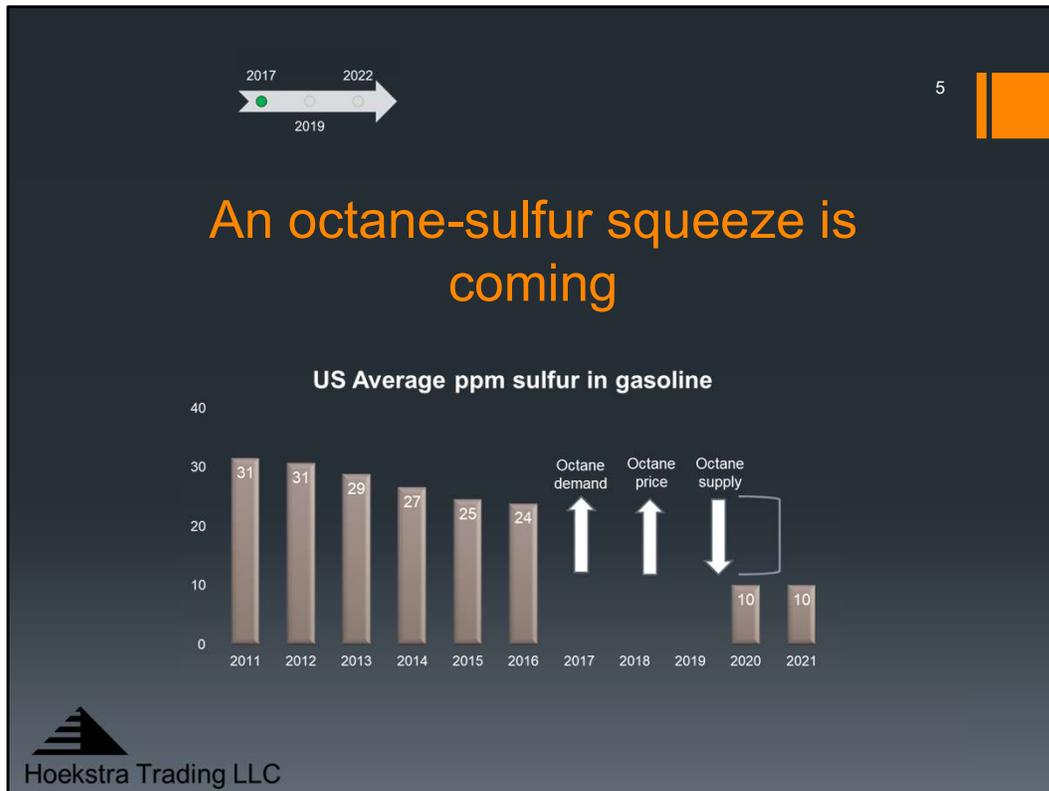
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This picture of a wolf comes from a previous talk of mine which Tom Kloza from OPIS titled Tier 3 gasoline - a wolf in sheep's clothing? It was a great title and it still applicable today so I am sticking with the wolf.

Three categories of FCC refinery



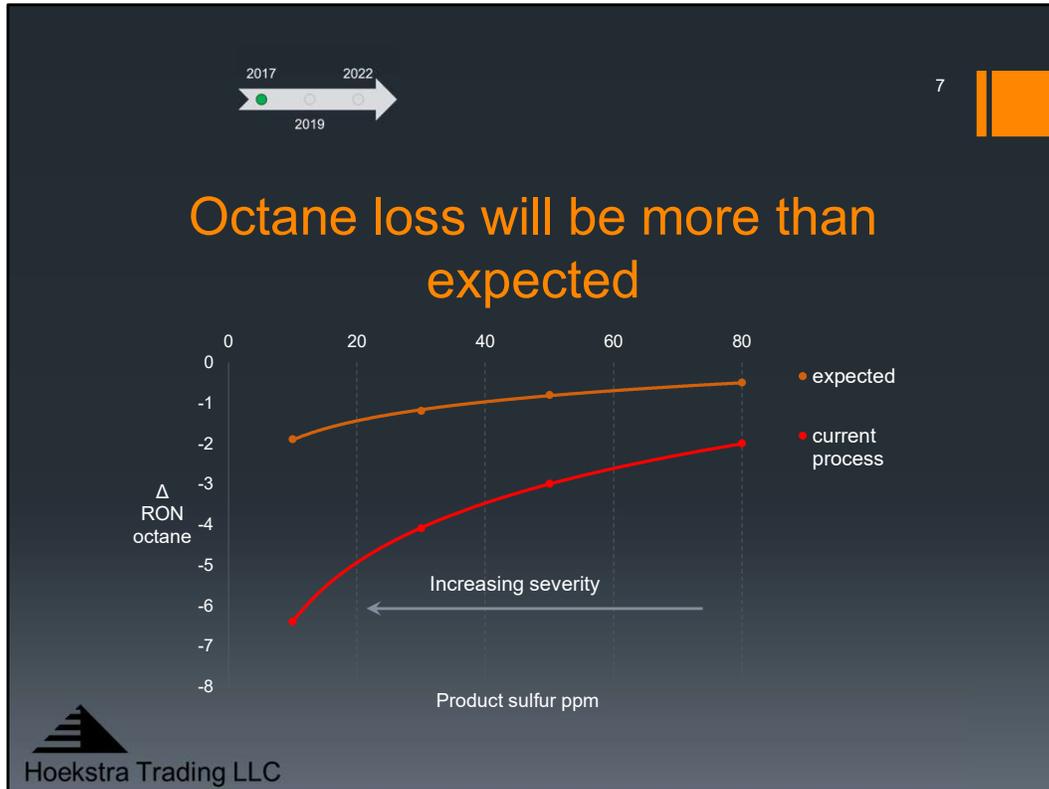
I will refer two three categories of FCC refineries: green, with a complete FCC train, yellow with no gasoline desulfurizer, and red, with no FCC feed hydrotreater. Green refineries have a huge advantage for making Tier 3 gasoline. Red refineries especially, have a huge disadvantage. They lack the FCC feed hydrotreater which is a high horsepower unit that removes a lot of sulfur and greatly improves the upgrade value and flexibility of the FCC train.



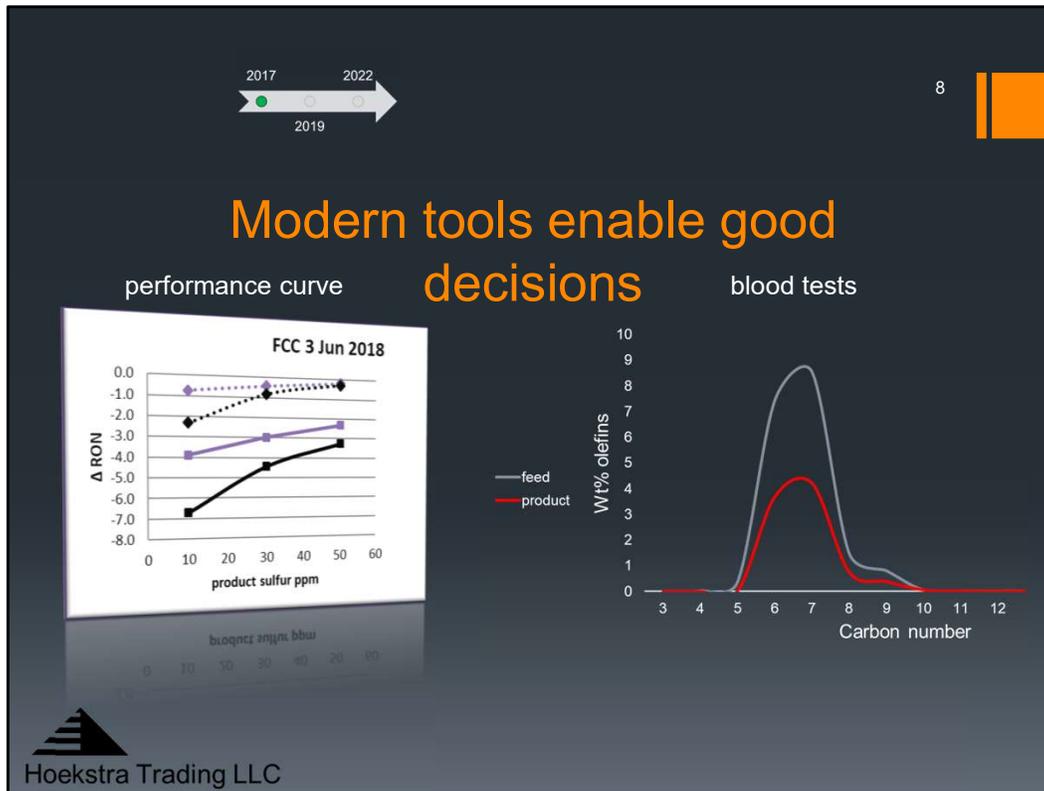
In 2017 we said an octane sulfur squeeze is coming. The average ppm sulfur in the us gasoline pool was declining slowly from 31 ppm in 2011 toward the Tier 3 requirement of 10 ppm by 2020. Contrary to popular opinion, we showed octane demand and octane price were increasing, and we predicted a large decrease in octane supply when refineries increase desulfurization severity to meet the Tier 3 specification.



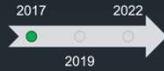
This chart shows the RON octane loss in an FCC gasoline desulfurizer as a function of the product sulfur level. We read this curve from right to left.



As we move from right to left, severity is being increased to reduce product sulfur and octane is being destroyed by side reactions in the gasoline desulfurizer. The red curve, from one of our field tests on a commercial unit, shows much more octane loss than the industry was expecting. Our pilot plant and field test data consistently showed this difference. The octane loss for Tier 3 would be much more than the industry was expecting.



Good data and modern tools enable good decisions. From our 3 year research project, which included lots of pilot plant and commercial field testing, we developed the performance curve spreadsheet model which accurately calculates octane loss versus product sulfur for any gasoline desulfurizer whose feed we have analyzed with what we call the blood test which is a very detailed hydrocarbon type analysis. The data and tools from this research project were delivered to our clients in three annual reports issued in October of 2015, 2016, and 2017, and are being used to optimize gasoline production, decide capital investments, and design new units.



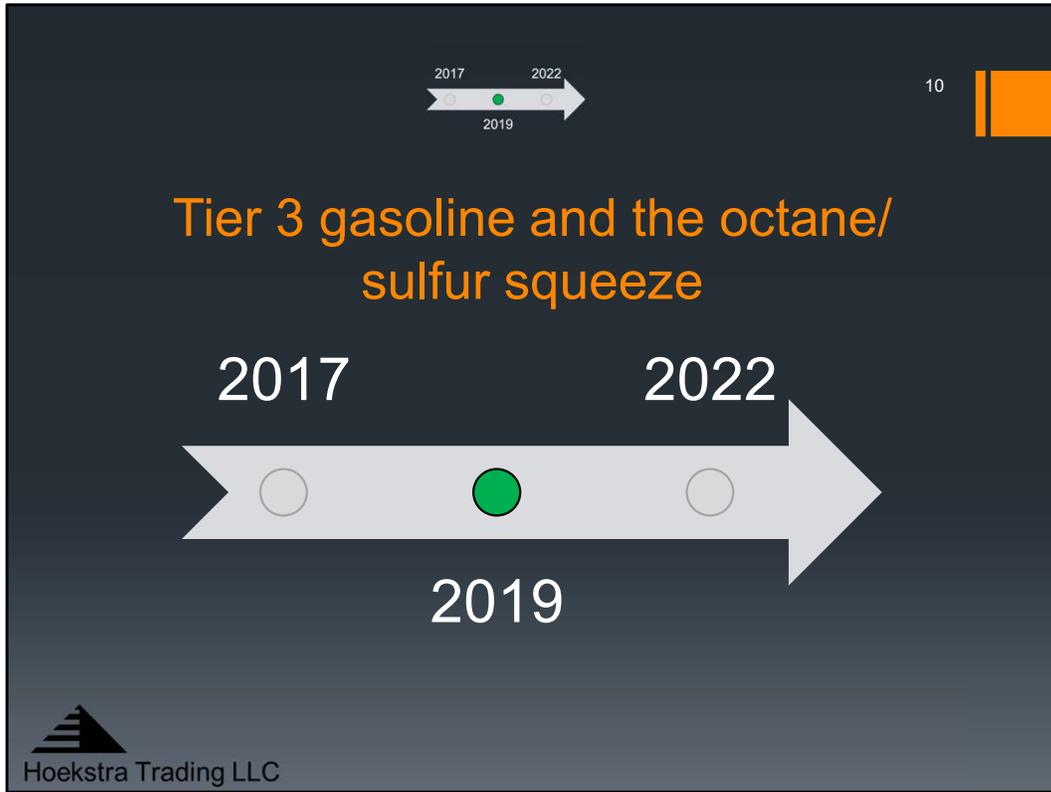
Predictions

- Compliance will stall until 2020
- Octane price will increase
- Latent constraints and bottlenecks will surface
- Refiners will scramble to make up lost octane
- Quarterly earnings will be affected
- Tier 3 readiness will be rewarded
- Tier 3 credit liabilities will accumulate
- Tier 3 credit price will soar

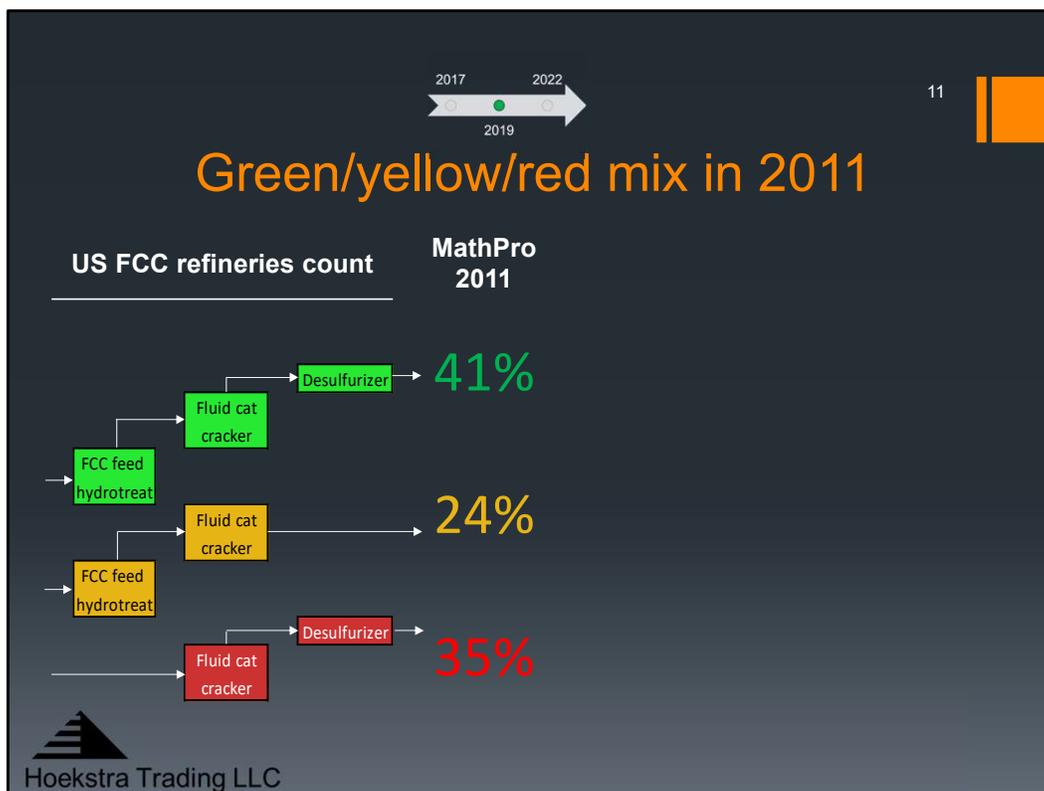
And in 2017 we made these predictions about how Tier 3 implementation would play out:

Compliance will stall until 2020 Octane price will increase Latent constraints and bottlenecks will surface in refineries. Refiners will scramble to make up lost octane

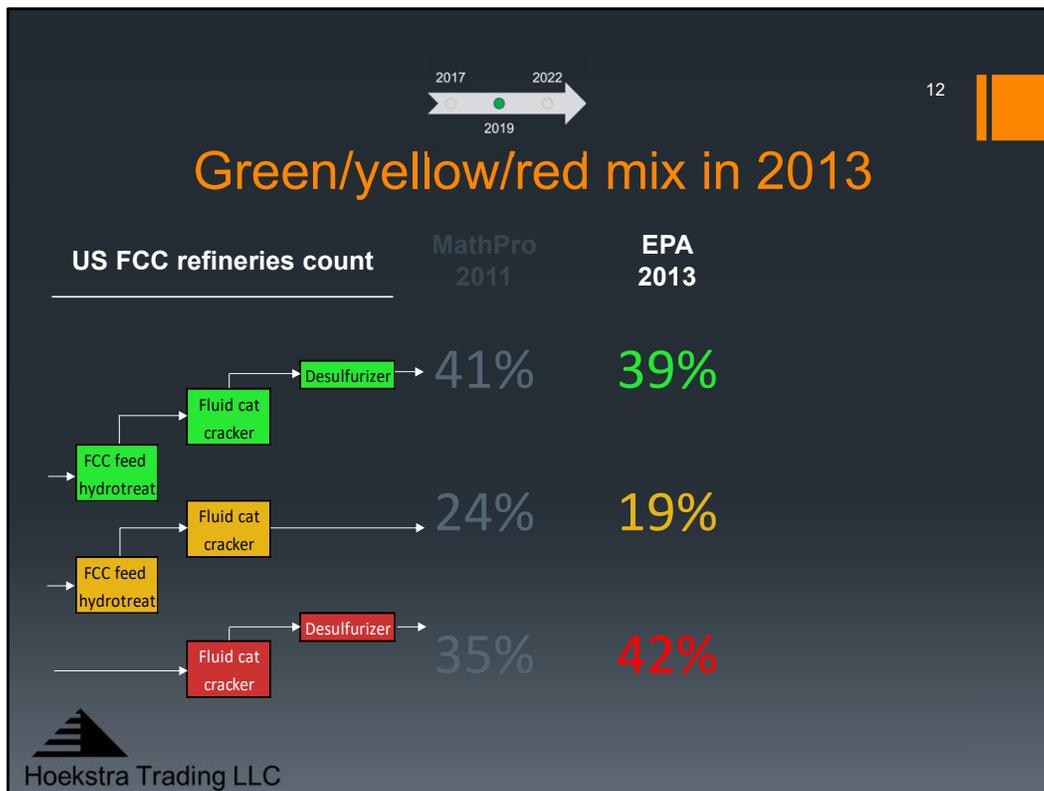
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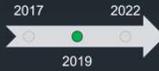
That was a high level review of our 3-year research project completed in 2017 and what we were saying publicly at that time. Now part 2. we fast forward to 2019, and you see my little timeline indicator on the top has now shifted to the middle for 2019.



In 2019, from data in a Tier 3 study done by MathPro in 2011, we counted 41% green, 24% yellow, and 35% red refineries in the USA.



Then we went to EPA's Tier 3 Regulatory Impact Analysis from 2013 and counted the same distribution which was 39% green, /19% yellow, /42% red. Recognizing the weaknesses of yellow and red refineries for gasoline desulfurization, these industry studies had estimated what would be required to bring the US refining portfolio up to a level that would allow Tier 3 gasoline to be made reliably and profitably in the US.



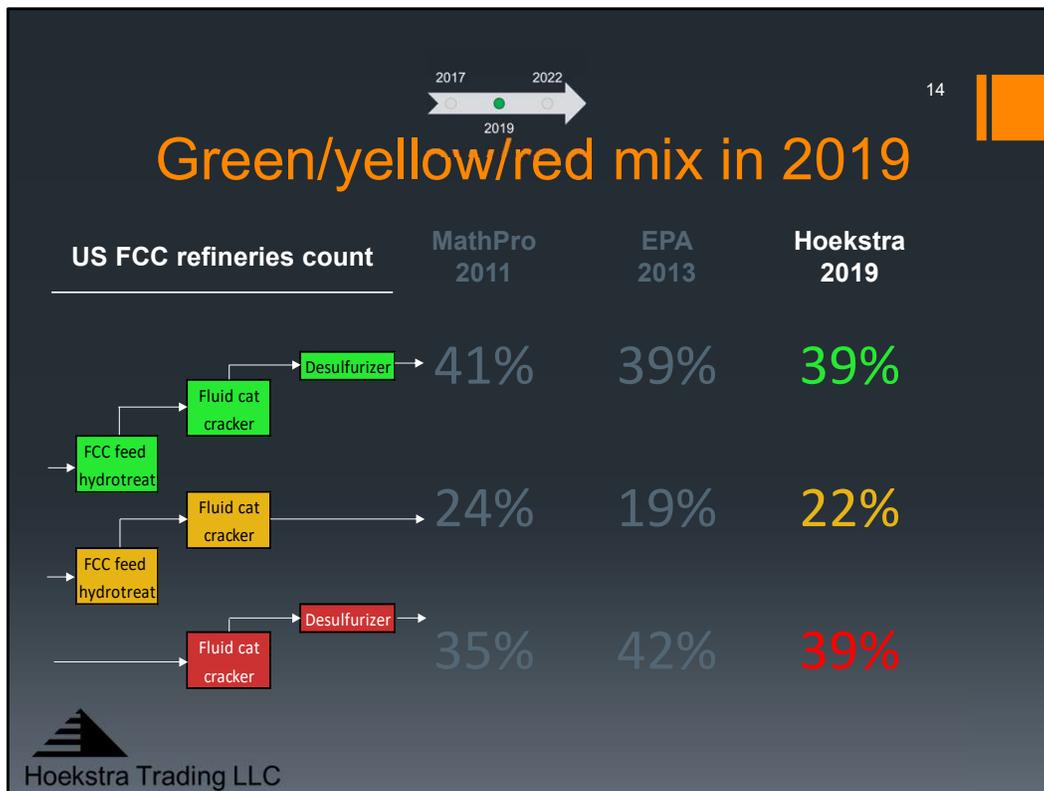
Industry Tier 3 studies said

- The US will need 82 capital investment projects
- 16 new builds and 66 revamps
- A six-year phase in will allow for these investments

= \$3 Billion in capital investment



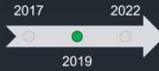
Those industry studies said the US would need 82 capital investment projects consisting of 16 new builds and 66 revamps of FCC feed hydrotreaters gasoline desulfurizers. A six-year phase in was allowed for these investments to occur. It added to \$3 billion in capital investment in FCC process trains. Baker & O'Brien estimate was \$10 billion dollars investment was required. All this was reported in detail in EPA's Regulatory Impact Analysis in 2013. So, in 2019 we asked how much of this necessary investment actually occurred? And the answer is almost none.



By our count in 2019, we were still 40% green, 20% yellow, and 40% red refineries. During the six-years allowed for Tier 3 capital investment, there were only a handful of projects targeted at what was clearly the weak link for Tier 3, which is getting sulfur out of FCC gasoline without destroying its octane. So, not only was the octane loss going to be higher than expected, but the necessary capital investment did not occur. Given those two findings, what would happen when the day of reckoning arrived?



We estimated \$10 billion per year worth of octane would be destroyed in gasoline desulfurizers when Tier 3 fully kicks in. How would refineries respond to this?



Refineries will face costly adaptations

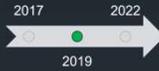


- purchase alkylate
- purchase toluene
- purchase sulfur credits
- downgrade FCC yields
- downgrade reformer yields
- downgrade gasoline streams
- restrict gasoline end point
- restrict feedstocks
- restrict black oil recycle



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They would face costly adaptations like purchasing octane, downgrading product yields and qualities, and restricting FCC train operations. Purchases, downgrades, and restrictions can allow refineries to cope with the squeeze, but they will take their toll on refining margin.



Costly adaptations will hurt

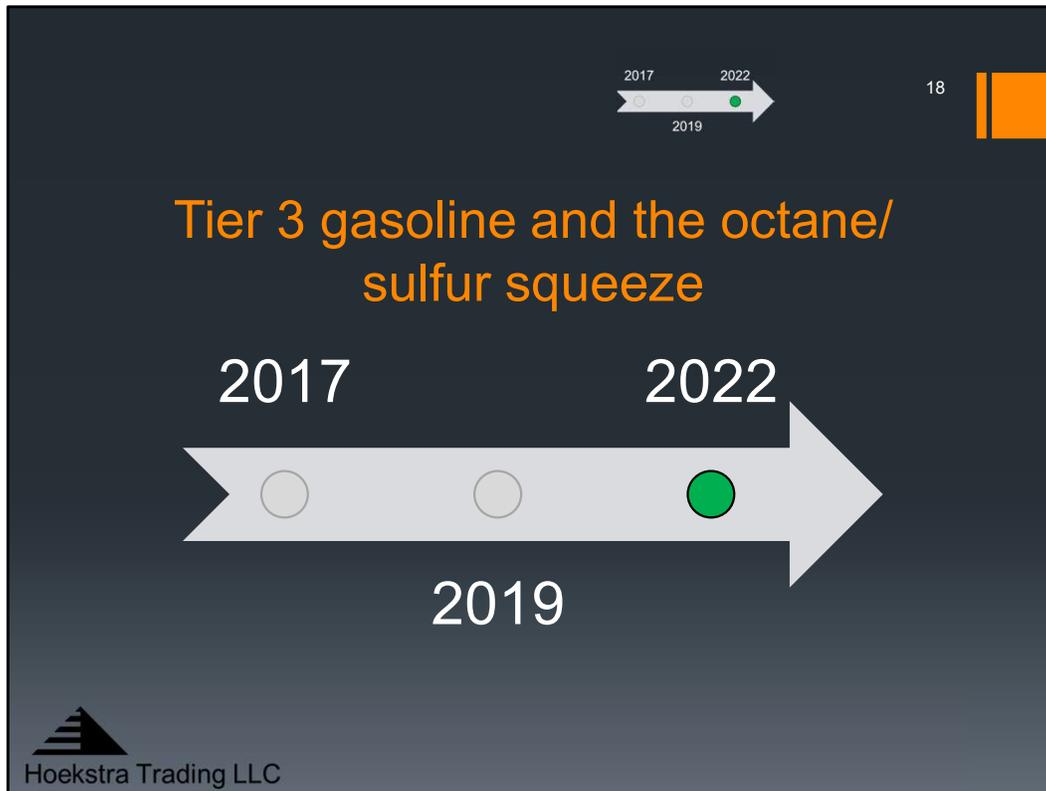


- premium gasoline production
- total gasoline production
- octane barrel production
- crude flexibility
- refining profit margin
- unplanned shutdowns
- credit liabilities

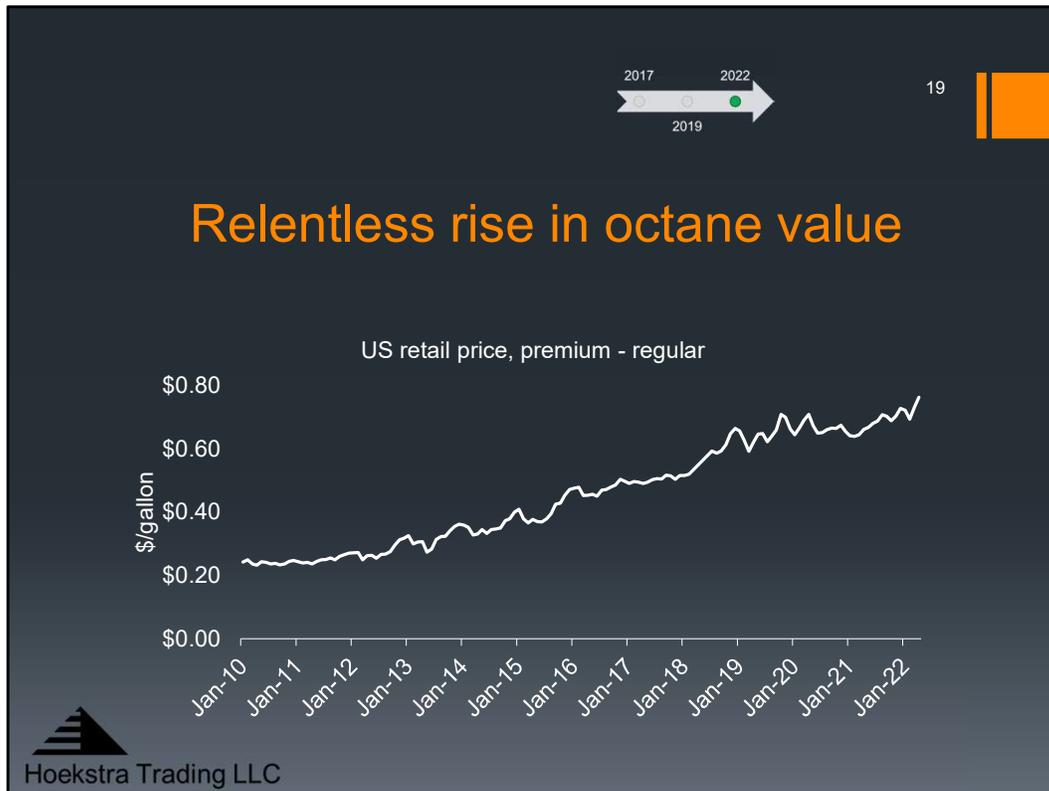


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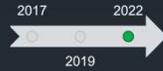
We predicted the costly purchases, restrictions, and downgrades will translate into lower premium gasoline and total gasoline production, lower octane barrel production, less crude flexibility, lower refining profit margin, more unplanned shutdowns and credit liabilities, all of which hurt margins



This was what we were saying in 2019. Now fast forward to today. Tier 3 has fully kicked in. Where do things stand?



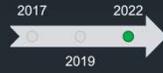
The relentless rise in octane value continues. The difference in retail price of premium versus regular gasoline in the US was 20 cents per gallon or less for decades, then ten years ago it started going up and has not stopped, still hitting all time highs every week as we speak. Contrary to popular opinion, the demand for octane in the US seems insatiable. And where, in US refineries, are most of the octane barrels made? In the FCC process train.



Predictions

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- Tier 3 readiness will be rewarded ✓
- Tier 3 credit liabilities will accumulate
- Tier 3 credit price will soar

Where do things stand on our predictions? Compliance did stall until 2020. Octane price did increase. Have constraints and bottlenecks surfaced in refineries? And are refiners scrambling to make up lost octane? I know that's happening in some refineries, in a moment I'd like to get some input from the room on these 2 predictions. As we will see in a moment, quarterly earnings have been affected and I will argue that Tier 3 readiness is being rewarded. Tier 3 credit liabilities have not yet accumulated Tier 3 credit price has not yet soared, but they will.

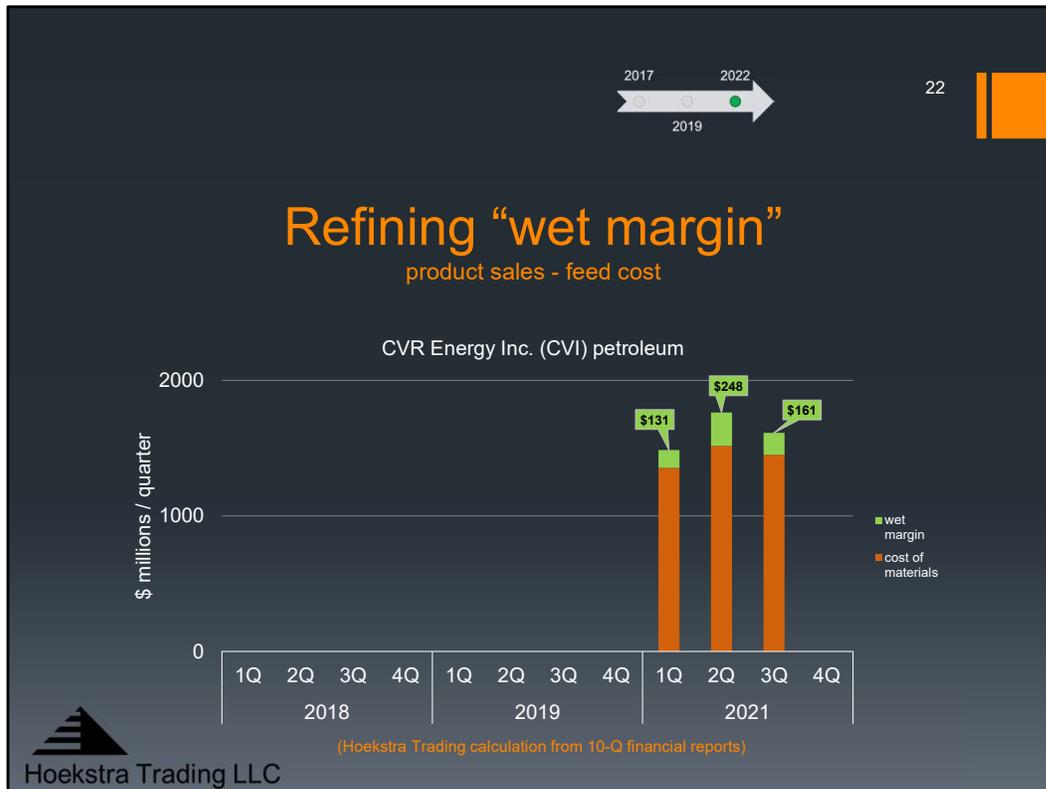


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Now for the rest of this talk I will focus on these two predictions, quarterly earnings will be affected and Tier 3 readiness will be rewarded



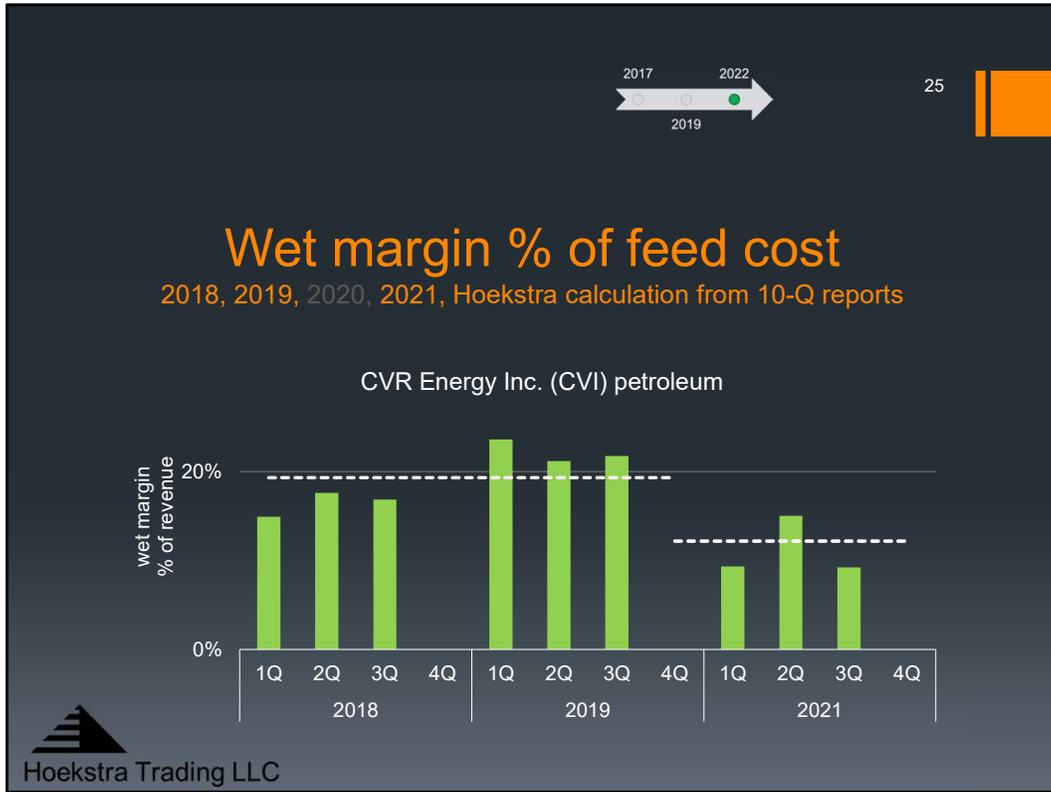
This is a metric I call “wet margin”. It is the value of refined products going out of the refinery in a quarter, minus the cost of feedstocks going in. It is shown here for CVR energy for the first three quarters of 2021. The orange segment is the cost of crude and other feedstocks, and the green segment is the additional value of refined products going out. I call the green segment wet margin because it is only about the cost and value of wet barrels flowing into and out of the refinery. It is similar to “refining margin” which is reported in refining companies’ quarterly 10-Q financial reports, but we adjust the refining margin for anything that’s not wet and flowing. The green bars show, for CVR, the wet margin ranged from \$131 million to \$248 million per quarter in 2021.



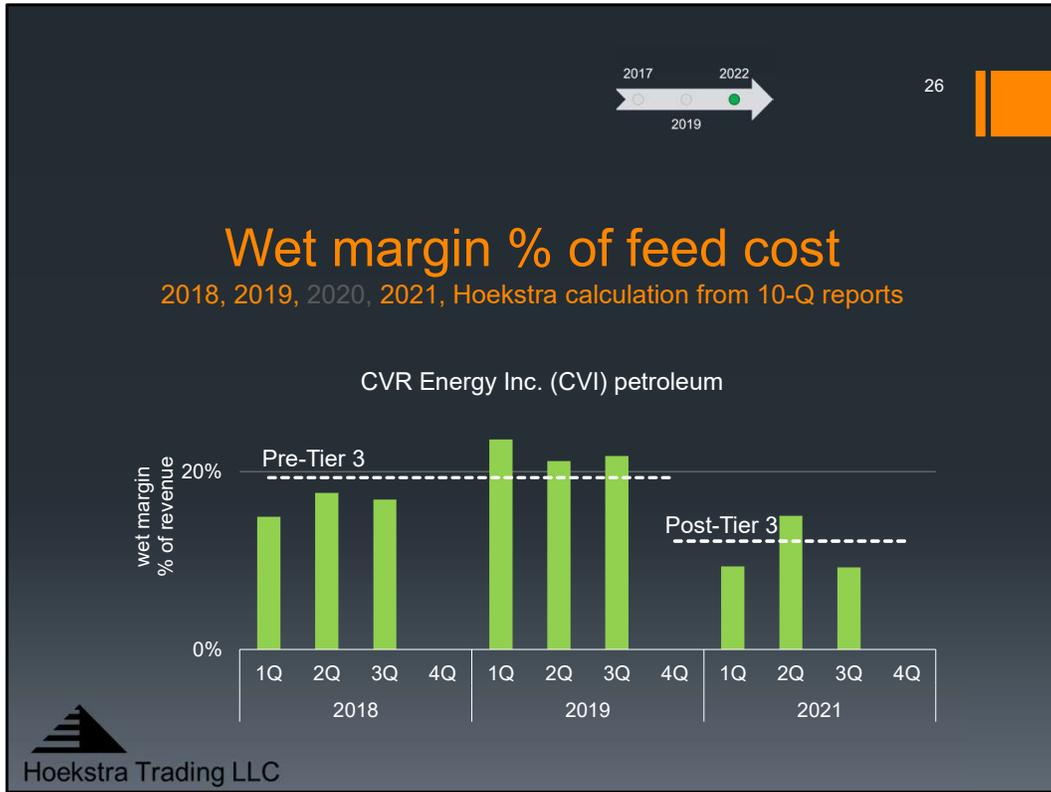
Now we are looking back to 2019, skipping 2020 which is the COVID lockdown year. We see in 2019, the green wet margin segments were much more than in 2021,



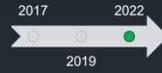
And in 2018, they were also more than 2021. We can look at these wet margins on a percentage basis:



On a percentage basis, the wet margin in 2018-19 was around 20% and in 2021 it was 12%. This could be called a pre-COVID vs. post-COVID comparison.



But it is also a pre-Tier 3 vs. post-Tier 3 comparison. And I believe this is a Tier 3 effect. Because of Tier 3, their realized margins on products leaving the refinery are lower today. That's my theory.



Wet margin % of feed cost

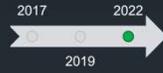
2018, 2019, 2020, 2021, Hoekstra calculation from 10-Q reports)

CVR Energy Inc. (CVI)
petroleum segment

PBF Energy (PBF)
refining segment



We made this chart for different refiners and compared them. Here is CVR on the left and PBF Energy on the right. PBF shows the same pattern pre vs. post Tier 3 as CVR. PBF's wet margins are lower than CVR's, which is interesting, but my point today is that both companies show lower margins after Tier 3 kicked in. This is some direct evidence quarterly earnings . . . have been affected by Tier 3.



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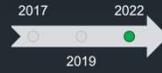
affected by Tier 3. Is there any evidence Tier 3 readiness is being rewarded?



This shows a steadily growing gap between the price of Marathon Petroleum Company stock in green and Phillips 66 stock in red, since the first trading day of 2021. Now some of you are thinking come on Hoekstra, are you going to claim your Tier 3 theory explains this? Yes I am going to make that claim, and I've been claiming that publicly since last summer. So stick with me here for a few more minutes while I make that argument.



If we zoom out on this chart, now setting time zero to July 2, 2019, so this now spans nearly 3-years, we see these two stocks move much in tandem until the divergence starts in 2021. In fact, if you look at a 10-year chart, this current divergence stands out as extraordinary even in a 10-year history. What is the cause? I say it is a shift in who is capturing bigger margins on gasoline.



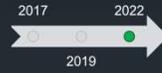
PSX - low refining margin capture

\$17.76 Market

\$3.92 Realized



This chart is from Phillips quarterly earnings report, it shows refining profit margin in dollars per barrel. The bar on the left is the market crack spread of \$17.76, that is Phillips benchmark for the refinery product margin in their market area. The rightmost bar shows that Phillips only captured \$3.92 of that \$17.76. The red and green bars between the market margin and realized margin show the factors contributing to that difference.

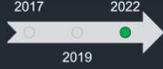


PSX - low refining margin capture

\$17.76 Market \$7.84 Other \$3.92 Realized



The big sore point is the red bar labeled “other”. It continues to draw the attention of financial analysts in quarterly earnings conference calls. It’s twice as big as the realized margin. What is that?



2017 2022
2019

33

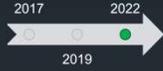
The “Other” category is

1. RIN costs
2. clean product differentials



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According to Phillips, the “other” category is mostly RIN costs and clean product differentials. I will not discuss RIN costs today, unless you want to later. What is meant by clean product differentials?



2017 2022
2019

34

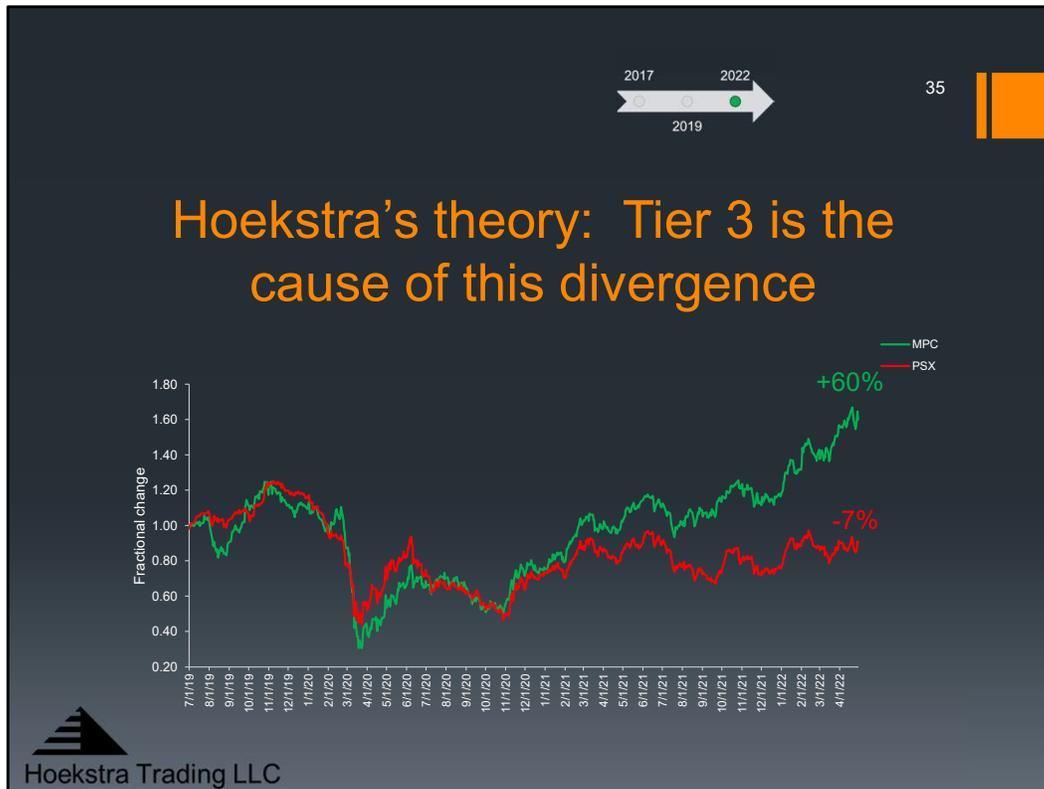
What are clean product differentials?

- Kevin Mitchell, Chief Financial Officer
- “Obviously, RIN costs were particularly high during the quarter. **Product differentials, which is the difference between the market indicator and actual product realizations, that one can move around and go both directions on us. During the quarter, those differentials we were not getting - seeing the value for some of those premium products that often can be a benefit to us in the quarter.**”



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Kevin Mitchell, Phillips Chief financial officer, says product differentials, which is the difference between the market indicator and actual product realizations, that one can move around and go both directions on us. During the quarter those differentials we were not getting - seeing the value for some of those premium products. This fits precisely the Tier 3 theory. So you see not only I believe my theory, so does Kevin Mitchell. Post-Tier 3, the naphtha being produced by the refineries is much less valuable. If a difficult new gasoline specification is suddenly limiting your ability to make marketable on-spec high octane gasoline, or downgrading the yield or octane of half your gasoline pool, or requiring you purchase alkylate or reformate from others, you will keep making gasoline molecules but you will not realize the market margin on them.



And if you have green refineries with big cat feed hydrotreaters AND gasoline desulfurizers, you can still make your own Tier 3 gasoline at low incremental cost out of cheap FCC feeds. So yes, I say the cause of this divergence is the Tier 3 specification which has handcuffed Phillips ability to capture the market margins on gasoline while Marathon can do that quite easily.

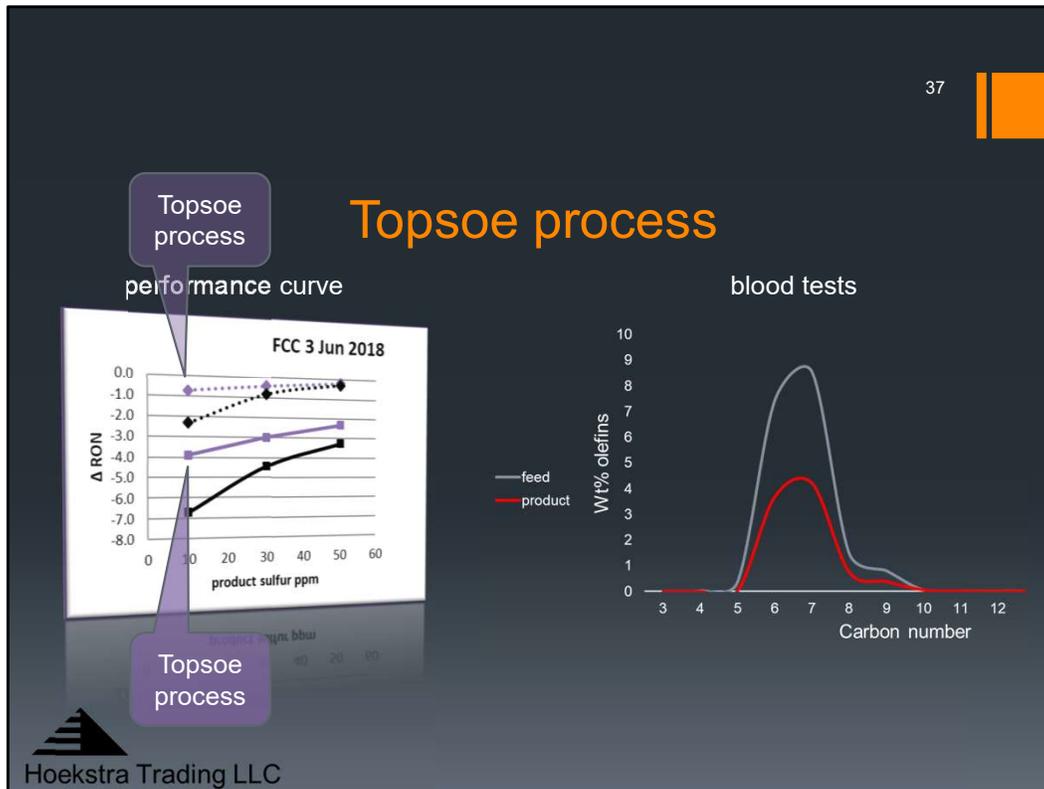
Tier 3 opportunities

- Tier 3 strategy
- Unit optimization
- Catalysts
- Capital investment
- Credit strategy



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What can red refiners do to address this competitive weakness? First, now is the time to re-examine your Tier 3 strategy. Our clients have used the results of our research to immediately improve their margins by unit optimization and choosing better catalysts without investing capital. Though it is not politically popular today, there should also be some capital investments in FCC train hydrotreaters to improve margin capture on the NON-RENEWABLE fuels that are the foundation of refining profit. While not wanting to be too critical of Phillips 66, I must note their capital investment budget this year is \$2 billion, none of which is aimed at improving margin on NON-RENEWABLE fuels beyond required maintenance and turnarounds. Why not invest some of the \$2 billion to improve refining margin capture? Even a fraction of \$2 billion would help a lot.



Improved, 21st century processes are available, like Topsoe's High Octane Technology which is a selective hydrotreating process that reduces octane loss by 40%. That improvement is represented here by the purple curves, compared to the black curves representing the 1990's technologies being used at most refineries today. Shifting this performance curve up, like the purple curves, can save 40% of the octane being lost with Tier 3. And even before that, refiners should be using the data and tools from our research to help optimize gasoline production make the best investment decisions. These tools were developed for refiners, specifically for the 21st Century, Tier 3 world and are available to anyone at negligible cost.



Conclusions

- Tier 3 is causing \$10 billion/y in octane destruction
- This is shifting margins to refiners best-equipped for Tier 3
- This is evident in refining margins and stock price
- Technology solutions are available for those wanting to improve octane/sulfur performance of FCC trains.



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I believe Tier 3 is causing \$10 billion per year in octane destruction in the US today, this is shifting refining margin dollars to refiners best-equipped for Tier 3, and this is evident in refining margins and stock prices. Good solutions are available for those wanting to immediately improve octane/sulfur performance in their FCC process trains, whatever spending you would consider, from \$75,000 dollars to \$2 billion dollars.

I recommend you should buy our reports on Tier 3 gasoline!



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A good next step for your company is to buy one of our research reports on Tier 3 gasoline and use it to help update your Tier 3 strategy. I suggest the third one, the most recent of the three annual reports we released. It's very easy to do. You just sign a purchase order and we deliver it at the speed of light. Find one profit-minded leader in your company to step up and sign a purchase order. It is very good work on an important topic that has been on the industry's back burner too long. The report costs \$75,000, which is a small fraction of the cost of the research and only about one minute's worth of your company's annual revenue. I'll be here today and tomorrow, please see me and I'll send you a link to the offer letter. That was my amateur sales pitch. And I will close by quoting a true professional salesman:

What have you got to lose?



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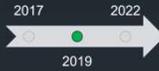
What have you got to lose?

Thanks for your attention!

- George Hoekstra
- george.hoekstra@hoekstratrading.com
- <http://hoekstratrading.com>
- +1 630 330-8159



Thanks a lot for your attention.



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