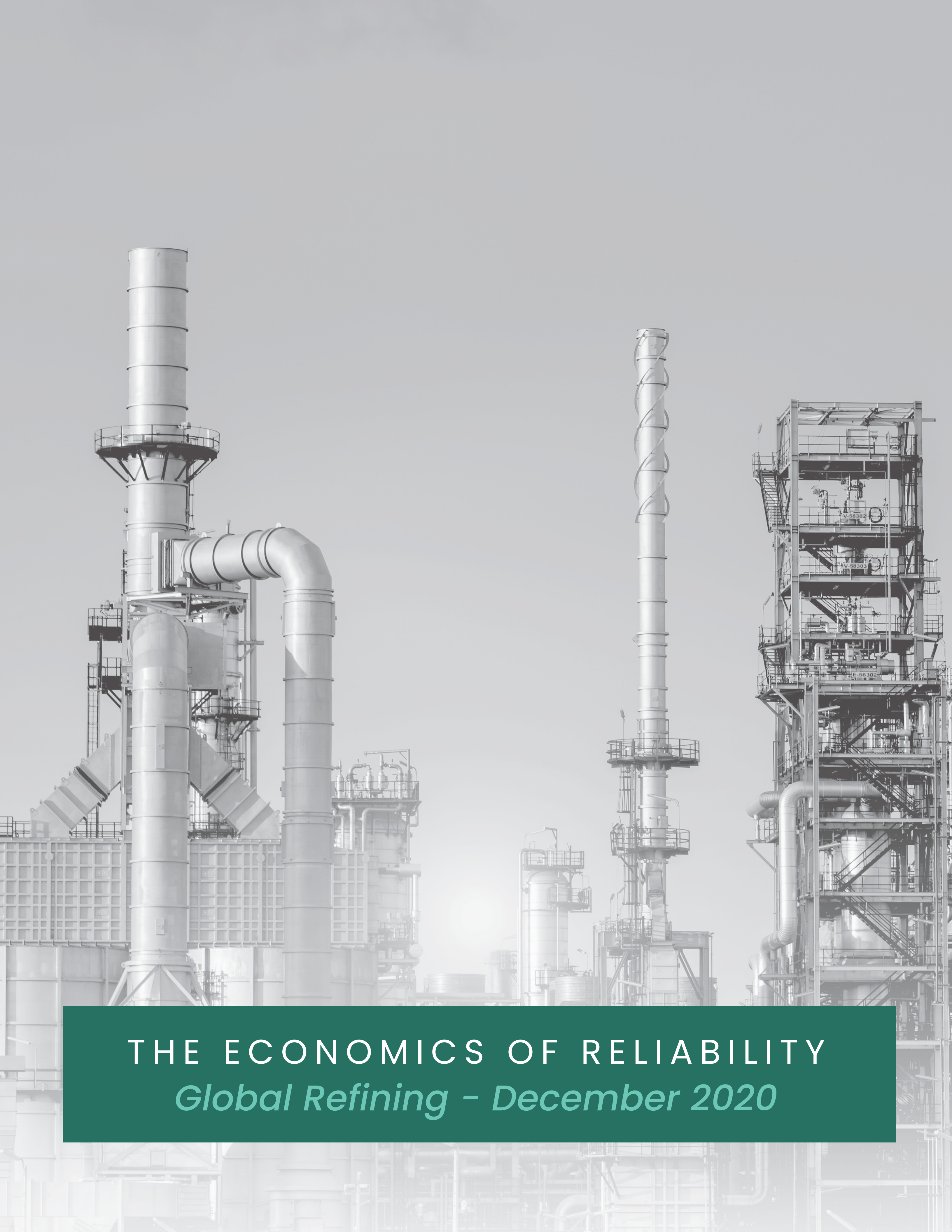
The Economics of Reliability

Interim Report - Global Refining

PINNACLE

DATA-DRIVEN RELIABILITY



THE ECONOMICS OF RELIABILITY

Global Refining - December 2020

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Reliability is a measure of how often something performs when you want it to.

LETTER FROM THE CEO

For over 20 years, I have worked as a direct employee or consultant for chemical plants, refineries, mining operations, and water treatment facilities. I've had titles like maintenance, production, and reliability engineer, to name a few. While my roles differed during my first years in the industry, most had the same objective – to determine how the facility could run more reliably while spending less money.

What is *reliability*? Most people think reliability is simply a measure of failure, or lack of failure. If something runs for a longer period of time without failing, then it is more reliable than something that runs for less time. However, we believe that reliability is a measure of how often something performs *when you want it to*.

Imagine a water treatment plant that continuously runs for three years and shuts down for two weeks. If a specific pump in that plant was to run flawlessly for three years but had to be rebuilt during those two weeks, it was as reliable as it was expected to be. The plant may propose upgrading the pump to last six years (two runtimes). If the definition of reliability was simply based on downtime versus uptime, then the new pump would be more reliable. However, if the new pump doesn't increase the plant's throughput or total runtime, then it's not more reliable than the original pump. This thought can be applied to other areas of our society. Is a car that needs more maintenance than another less reliable? Most would say no, as long as it works when they want it to.

Throughout the developed world, the systems we depend on are running longer and longer. We expect our systems to operate reliably and as a result, we are conducting more integrated analysis with data and are using machine learning and artificial intelligence to maximize total system productivity. As our processes continue to evolve, our definition of reliability must evolve as well.

I explore this evolution of reliability in my book, *Crucial Decisions*, which was released earlier this year. I also lay out the reasons we should focus more on optimized performance instead of longest performance. At Pinnacle, we take this view, and define reliability as the amount of time a system, process, or component runs when you want it to. In other words, reliability is the balance of cost and performance that yields the best return. Through our analysis, we have found four reliability-focused things that a refiner can do to have a lower risk profile and higher profitability result, proving the correlation between reliability and profitability. We explore this analysis throughout this report and revisit it again in the conclusion.

The basis for our annual and interim quarterly reports is to explore the connection between reliability and economics so that we can understand how these key components of modern society intertwine. In doing so, we begin to see some striking trends and key indicators of opportunity. Our goal for these reports is to challenge key industries in ways we never have before.

I look forward to the discussions that follow.

Sincerely,
Ryan Sitton
Founder and Chief Executive Officer

Operators around the world spend an estimated $500 billion annually on reliability.

INTRODUCTION

Most of the world's major industrial facilities buy and sell commodities. Therefore, they have little impact on the price they pay for their feedstocks or the price they receive for their products. The nature of every commodity is that producers will fill the market with enough product until the margins, or profits, for producing that product drop so that no one will produce more. That balance of supply and demand will, inevitably, separate out the organizations that are very good at running the facilities from those who are not. One of the biggest differences between these two groups is reliability.

Whether discussing jet transportation, power generation, water processing and treatment, chemicals, mining, oil and gas production, refining, automotive manufacture, or agriculture, reliability can mean the difference between excellence and mediocrity, and even profitability versus bankruptcy.

Pinnacle analysts estimate **operators** of complex facilities around the world spend over $500 billion annually on reliability. Our aim is to view several of these segments in detail and better characterize the role reliability plays in the broader economy.

> **OPERATORS** are companies, agencies, or institutions whose personnel directly oversee the day to day functions of complex process facilities and make the long-term financial and strategic decisions about the facility future.

Pinnacle's Global Reliability & Profitability Reports are a series of reports that explore the world of reliability in petroleum refineries, wastewater treatment plants, and other complex process systems. For the purposes of our studies, we evaluate reliability as the measure of how often these systems perform when their operators intend them to. This report uses data-driven approaches to study reliability – both its costs and benefits – in the most impactful industrial sectors across the global economy.

These reports have three objectives:

- ***Quantify the amount of investment facility operators make on reliability today***
- ***Describe how best-in-class operators achieve superior reliability***
- ***Estimate the benefits of market-wide reliability improvement***

Each year, Pinnacle will publish an annual report and three interim reports. The annual report will cover higher level analyses of the role reliability plays in several critical global industries, and therefore the role of reliability on global and regional economics. Interim reports will share a deeper investigation into focused industries or segments and reference market-moving current events in other sectors.

ABOUT THIS INTERIM REPORT

This interim report focuses on petroleum refining. Data from governments, operators, and research services form the foundation of our analysis. Using this data, we built our own models to calculate the **intensity of reliability spend** for a range of companies worldwide.

> **INTENSITY OF RELIABILITY SPEND** is a measure of reliability spend on a per unit basis, which, in this report, is often per barrel of throughput.

In this report, we describe the operational and financial realities that shape the global refining landscape. The recent historical performance of refiners helps us understand the status quo and establish expectations for the future, which we share at the conclusion of this report.

Our analysis revealed numerous interesting insights:

- ***Reliable operation is the largest correlative indicator of profitable operation***
- ***All reliability spend is not created equal***
- ***North American facilities provide a roadmap for designing and executing optimal reliability programs***
- ***Two US independent refiners have demonstrated clear differentiation from the rest of the refining segment***

We will describe the analytical approach, visualizations, and context that helped us determine these insights.

WHY EXPLORE REFINING?

We chose to focus our first interim report on petroleum refining for several reasons:

- ***Refining is at the epicenter of the world economy, meaning the impact of this segment is massive***
- ***There is a significant amount of data available on refineries, from public company reports to government agencies***

- ***Refineries all have the same basic function and outputs, making them easy to compare***
- ***While ownership profiles vary around the world, strong incentives exist for every facility to optimize its reliability***

For decades, lean manufacturing has driven companies and operators to improve runtimes, lower costs, and minimize risk for their facilities. While this push has affected multiple sectors such as airlines, automotive, power generation, and mining, no area has produced as much public data as the refining sector, especially in the US. The Energy Information Administration (EIA) has collected and reported refining data for decades, and when combined with international reports from The Organization of the Petroleum Exporting Countries (OPEC), Saudi Arabia, and the International Energy Agency (IEA), among others, the level of information is unparalleled to other sector reporting.

There are approximately 700 refineries in the world – only 400 of notable **throughput** – that all have the same basic function and process.

> **THROUGHPUT** is the volume of liquids processed in a given period of time.

For the purposes of this study, Pinnacle analysts treated all oil and refined products such as gasoline, diesel, jet fuel, and kerosene as globally fungible commodities, meaning that no one region, country, or company has an outsized market value for their products. Short-term market conditions do give certain producers a regional advantage either through access to crude or to consumer markets, but when weighing the long-term markets, these advantages are minimized. Given the uniformity of plant-level functions and outputs, the refining sector provides the most complete model to evaluate global reliability.

Finally, fewer than 300 refineries account for 80% of the world's refining capacity,[1] which is concentrated heavily in the United States, China, Russia, India, and a few other nations with developed oil and gas infrastructure. In the US, refineries are all owned by private corporations and do not receive direct public support or funding from the government. Outside North America and Europe, refineries are owned and operated by a combination of government and public entities in partnership with private corporations or other nations and are heavily subsidized by government finances. Because of these differences in funding and ownership, the incentives to improve reliability in US refineries versus global refineries may differ in the short run. However, to ensure the ongoing performance of their facilities, all operators have the incentive to optimize reliability in the long run.

As of December 2020, an estimated two million bbl/d of refining capacity is out of the market, versus the beginning of 2019.

REFINING RELIABILITY OVERVIEW

First, we must understand the macroeconomic landscape for global refiners. Operators across the world are experiencing financial pressures as illustrated by the state of the markets for feedstock and finished products. We will explore these markets and describe their impact on reliability programs in the refining space.

CRACK SPREADS AS HEALTH INDICATORS

A refiner's financial performance is largely driven by two variables – the price of raw feedstock, e.g., crude oil, and the price of finished products, e.g., gasoline, diesel, and jet fuel. As a result, **crack spreads**, the difference in prices between finished products and feedstocks, are the most useful indicators of the health of the refining sector.

> **CRACK SPREAD** is the difference in price between refined product(s) and chosen input(s).

Importantly, crack spreads do not account for the cost of running the plant. Crack spreads ignore costs for items like the energy to heat and process the feedstock; the people to operate the plant itself; and all the repair, maintenance, and ongoing reliability work.

If we are most interested in reliability, then why do we care about crack spreads? Over 80% of the costs for a refinery are its feedstock. Crack spreads help us understand what is left over when we remove a refiner's single largest cost from its theoretical revenue. This leftover amount is what the refiner uses to cover its remaining costs, with ideally some profit remaining at the end. As crack spreads widen, the refiner has more capital available to invest in its operation or return to its owners. As crack spreads narrow, refiners have less flexibility and need to make difficult decisions about how to deploy their limited capital. Crack spreads tell us about the resources available to invest in best-in-class reliability programs, which is our primary area of interest.

While crack spreads inform us of the health of refiners, they are not perfect benchmarking tools. Refining costs are generally organized in similar categories, but the nature of these costs can vary widely between companies and facilities based on turnarounds, contracts, personnel costs, and regional shipping issues. For example, the average refinery in California must pay higher prices for electricity, natural gas, and personnel than the rest of the United States due to stronger regulatory forces. In addition, they must also pay higher taxes and fees on their products and resources. As a result, with the same crack spread and same operating conditions, a California refinery may have dramatically lower operating margin than other refineries in the US.

REFINING FINANCIAL LANDSCAPE

Figure 1 (below) from the US EIA gives us one measure of crack spread from 2006 through September 2020. The blue line (left axis) shows the spot price for Brent, the international benchmark for light, sweet crude oil. The green lines (right axis) show the crack spread between reformulated blendstock for oxygenate blending (RBOB) – the primary component of gasoline – and Brent. The solid green line shows the monthly average crack spread. The dashed green line shows the crack spread's trailing one-year average.

To be clear, no single crack spread capably describes the commercial performance of all refineries around the world. Because our interest is in reliability, we will not analyze more complex crack spread metrics or their inevitable regional variances. We simply rely on the spread between RBOB and Brent as an indication of the tailwinds or headwinds experienced by the refining sector at large.

This chart shows the volatility through which refiners have learned to manage their businesses. Since the beginning of 2006, the smallest monthly average crack spread was $0.01 per gallon, while the largest spread was $1.32 per gallon. In this window covering nearly sixteen years, the crack spread has averaged $0.40 per gallon. In comparison, the 2020 year-to-date average is $0.30 per gallon, a 25% drop from the historical norm. If we use consumer price index data to account for the time value of money, the average crack spread from 2006 to the present increases to $0.46 per gallon. In constant dollar terms, the 2020 year-to-date spread is then at a 35% discount to the historical average, which explains a large fraction of the prevailing distress across the global refining sector.

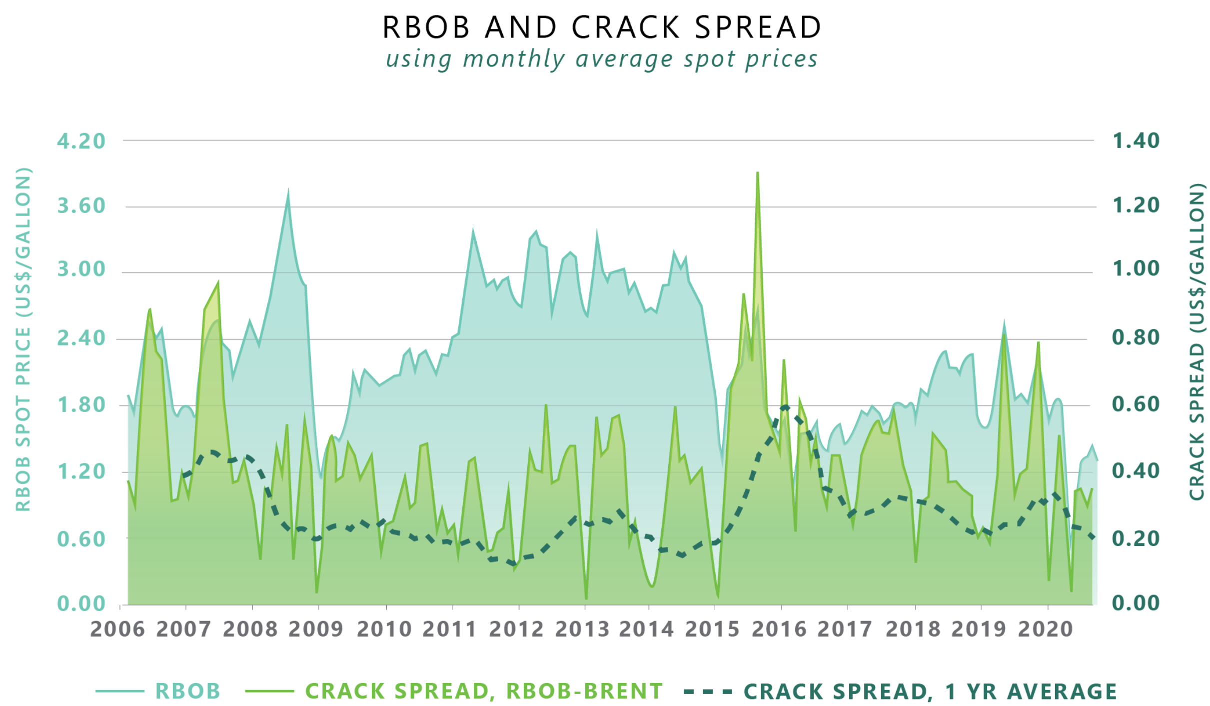


Figure 1. RBOB spot price and RBOB-Brent crack spreads[2]

We can see some interesting patterns in this data set. Starting around 2010, aggressive development of United States unconventional oil and gas plays brought excess supply to the market. This supply glut eventually caused a crude oil price collapse at the end of 2014. Demand, on the other hand, did not experience a similar shock, which kept product prices from collapsing as aggressively as crude oil prices did. As a result, crack spreads climbed through 2015. Over the course of a year or so, refined product prices reset to the lower oil price regime, which caused crack spreads to return to their normalized level around $0.40 per gallon, where they remained from 2017 through 2019.

As noted previously, the 2020 year-to-date crack spread average is about 35% below historical levels when measured in constant dollar terms. The initial decline was triggered by a rapid deterioration in refined product consumption, driven by government lockdowns in response to the COVID-19 pandemic. Refined product consumption has only weakly recovered as government restrictions persist, combined with (at least temporarily) changing travel preferences among the general population. As a result, crack spreads have seen continuous pressure throughout the year, with the most vulnerable refineries experiencing negative margins.

Part of the reason crack spreads have not deteriorated further is because refiners have throttled back their **utilization**,[3] and in some cases, have closed plants entirely.[4] Where possible, refineries are being repurposed, often with a focus on producing biofuels.[5] If all these refineries had remained as they were historically configured and had run at the higher utilization levels we saw in the recent past, finished product prices would have collapsed further and squeezed refining margins even harder. While less capacity and fewer refinery runs help preserve crack spreads, refiners must make do with fewer revenue and profit dollars as a result.

UTILIZATION is a fraction whose numerator is the facility's actual output and whose denominator is the facility's nameplate capacity, i.e. its capacity if it was capable of continuously running at 100% throughput.

The news is not all bad for refiners. Capacity reductions will accelerate the pace with which the market normalizes. As of December 2020, Pinnacle analysts estimate that two million barrels per day of refining capacity is out of the market, versus the beginning of 2019. Therefore, the market should reach a healthy balance of consumption and production in 2021. Assuming this to be the case, Pinnacle analysts are forecasting an upward trend in refining margins for the next five-year period through 2025.

FRAMING RELIABILITY IN REFINING

Our crack spread analysis tells us that refiners are fighting an uphill battle in 2020. Today's compressed spreads mean fewer resources are available to sustain operations of facilities around the world. When evaluating an individual refinery, the facility has little control over the relevant crack spreads. Instead, the operators of the plant can do three things to improve operating margins:

- Run the facility more efficiently, minimizing energy costs while maximizing the value of the product mix
- Run the facility more frequently, with a lower ratio of downtime
- Lower costs associated with maintenance, repairs, turnarounds, personnel, equipment, etc.

Items two and three above are directly impacted by reliability. A facility with more reliable systems can perform less work on that equipment. Similarly, more reliable equipment allows the facility to run a larger portion of the time. Therefore, the upper limit of the amount of improvement through more reliability is the scenario in which a refinery runs 100% of the time and spends nothing on equipment maintenance or repairs. While this scenario is practically impossible, it does frame the magnitude of the value analysis. In addition, it provides the measuring stick to evaluate refiners in their current operating condition.

It is important to make a note about vocabulary here. Many industrial facilities use the terms reliability and availability to identify the difference between the run time of a piece of equipment (reliability) and the ability of equipment to run when desired (**availability**). For example, if unit margins are so low that a company decides to shut a unit down, then it is still available, just not utilized. Since the unit was taken down, the reliability calculation for the individual equipment items in it may appear lower due to the downtime. Hence, most refiners focus more heavily on availability to draw out the information in which they are most interested.

AVAILABILITY is the fraction of time a facility was in condition to run, relative to the time it could have run (its nameplate capacity).

For the purposes of our analysis, we look only at the system, or facility, level. In other words, the individual equipment reliability is only valuable when the system runs, when it is desired to run. Therefore, from a system-level, reliability and availability become nearly synonymous. And, since many other industries do not distinguish reliability from availability, it is appropriate to quantify value of the system reliability to compare.

ANALYSIS METHODOLOGY

STRUCTURE AND SOURCES

When working to understand the impact of reliability, the primary focus is on the economics of reliability. In other words, how much is spent on reliability and how much is gained from that investment? Across the refining segment, several financial categories can contain those expenditures, including investments, capital expenditures, special projects, reliability projects, maintenance costs, turnaround expenditures, and more. Anecdotally, most refining companies have broad categories of **maintenance** and **turnarounds**, which capture nearly all the regular expenditures that are designed to maintain or improve reliability. The other main category for reliability expenses is capital projects that are intended to boost reliability, but these projects are a relatively small segment.

MAINTENANCE is routine activities with the purpose of maintaining the working order of productive assets.

TURNAROUNDS are infrequent, intensive activities aimed at maintaining the working order of productive assets, which often involve taking the assets in question offline in advance of or during the work.

To calculate the financial investments that refiners are making to drive reliability, we modeled refinery operations from around the world, separating refinery operating expenses into four segments:

- Cost of energy – cost of all energy inputs to the refining process, primarily electricity, natural gas, and steam
- Cost of labor – cost of full-time employees and contractors to sustain refinery operations
- Cost of reliability – cost of all standard run and maintain and turnaround activities independent of personnel costs in these areas
- Other costs – miscellaneous costs that do not fit cleanly into the above categories, e.g., property taxes, insurance premiums, telecommunications infrastructure and service, etc.

Although these segments are not reported publicly, Pinnacle models were developed using algorithms that leverage publicly available data coupled with deep experience in refinery operations. For this analysis, we relied primarily on six data sets as inputs:

- Total capacity and throughput for global regions outside of the US[6]
- Total capacity and throughput for the US[7]
- Throughput and operating expense information at the facility level for 2017 and 2018, for a portfolio of refineries comprising over 90% of the world's capacity[8]
- Throughput and operating expense information at the enterprise level for 2017, 2018, and 2019, for independent US refiners and international operating companies with substantial presence in the US[9]

- Estimates of electricity prices for the largest energy consumers around the world, used as a proxy for input energy costs for refiners[10]
- Estimates of national labor costs in the manufacturing sector, adjusted to account for the fact that refinery workers typically are more highly skilled and more highly paid than the average manufacturing laborer[11]

PINNACLE RELIABILITY ECONOMIC MODELS

Pinnacle Reliability Economic Models start with all-in operating expense data at the facility level, and subtract out the effective cost of energy, cost of labor, and other costs. The country or region in which the refinery is located is used to determine what adjustment is made for cost of energy and cost of labor. Assumptions are made for remaining miscellaneous operating costs. What remains is the cost of regular maintenance activities.

Most turnaround activities are capitalized and not included in operating expenses. Based on our own assessments and past work with refiners, we have established estimates that correlate turnaround costs to operating and maintenance costs. Adding the spend on run and maintain activities to the spend on turnarounds gives us our total estimated reliability spend.

Typically, turnaround programs involve catalyst changes and other activities that are not commonly defined as being related to reliability. In our view, catalyst changes have a meaningful impact on reliability, since these changes are necessary for the plant to operate optimally. We deliberately expand our view of reliability beyond simply the activities whose immediate intent is to prevent adverse health, safety, and environmental events. Because turnaround programs are designed to maintain long-term facility-wide performance, we view the corresponding spending as part of the plant's reliability program.

Finally, the refinery operating expenses data we rely on is already net of cost of material and transportation, so crack spreads are not included in this part of the analysis.

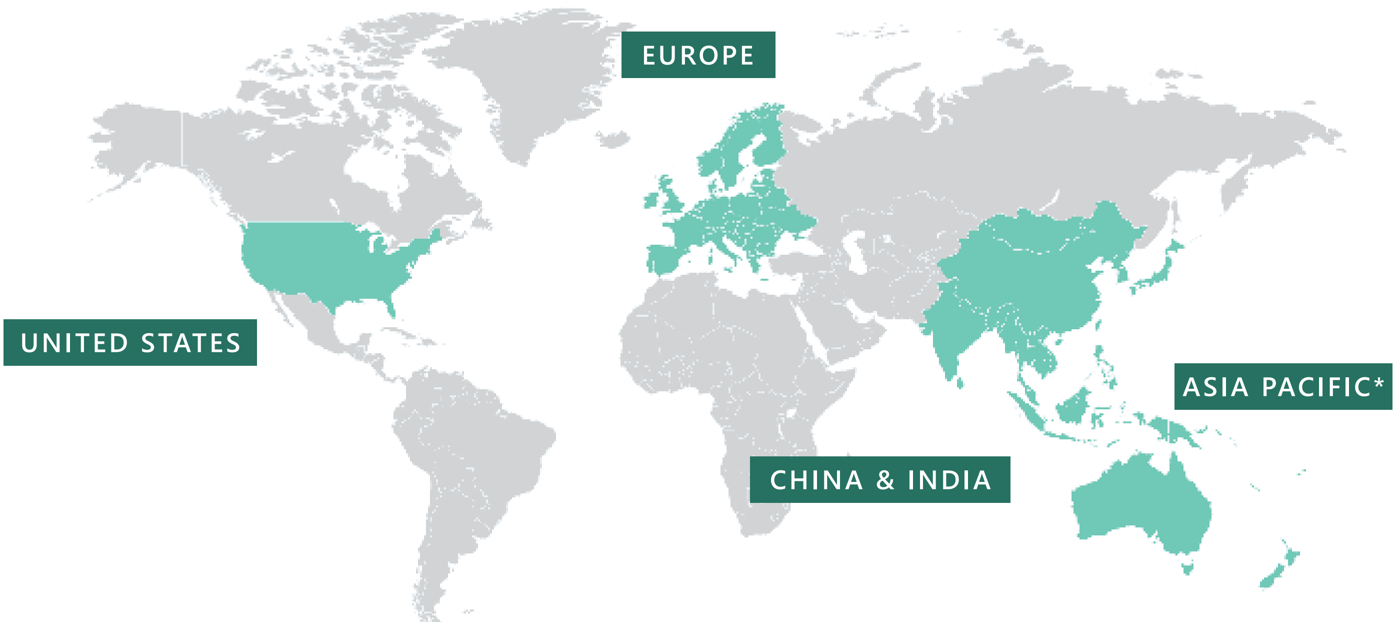
Pinnacle makes some implicit assumptions by pursuing this methodology and ignores the impact of government subsidies on refinery operations. Through cost of energy and cost of labor metrics, we do our best to make like-for-like adjustments to refinery cost structures around the world. Given the global scope of our analysis, we have also assumed each refinery is being run as efficiently as possible given realities around current technology and infrastructure.

The output of our methodology is an estimate of the reliability spend associated with each refinery of note around the world. For a summary view, we roll up the results at the region level. For more detailed views, we roll up the results at the enterprise level.

RESULTS

SUMMARY

In this section, we will share an overview of the reliability performance of refiners from four high-throughput geographical regions around the world:



Excluding China and India

We learn that, of these four regions, Europe has the lowest estimated reliability spend intensity, at $1.20 per barrel of throughput. The US has the second lowest intensity, at $1.60 per barrel. The two remaining regions, which collectively span all of Asia Pacific, have considerably higher spend intensity, at $2.30 per barrel.

We have two important pieces of information that help us understand the impact of reliability on a refiner's performance:

- Utilization
- Estimated reliability spend intensity

The worst-case scenario for a refiner is when utilization is low, but reliability spend intensity is high. In this case, the refiner is spending more than average to achieve worse than average results. The best-case scenario is when utilization is high, and reliability spend intensity is low. In this case, the refiner is achieving preferred operational results at less than average spend levels. In the subsections that follow, we will explore the intersection between utilization and reliability spend for the four high-throughput regions we previously listed.

GLOBAL OVERVIEW

Before diving into the performance of specific refiners, we will give an overview of the global refining industry. Table 1 shows some key operational and financial performance indicators for different regions around the world. Even at this high-level overview, we can identify some important trends that offer context to the higher resolution results we will explore later.

Region	Total Capacity (bbl/d)	2019 Throughput (bbl/d)	Utilization	Cost of Energy (Index)	Cost of People (Index)	Operating Cost (US$M)	Estimated Reliability Spend (US$M)	Opportunity (US$M)
US	18.8	17.0	90%	1.0	1.0	27,600	10,100	1,010
Canada	2.1	1.8	86%	0.8	0.8	2,300	1,100	110
Mexico	1.6	0.6	38%	1.4	0.6	700	100	10
China	16.2	13.4	83%	0.9	0.6	16,500	10,400	1,040
CIS*, including Russia	8.3	6.9	83%	0.7	0.7	6,200	1,500	150
India	5.0	5.1	102%	1.0	0.6	8,300	4,900	490
Europe	15.7	12.7	81%	1.5	0.9	21,200	5,700	570
Asia Pacific**	14.3	11.7	82%	1.1	0.9	20,400	10,700	1,070
Middle East	10.0	8.5	85%	0.7	0.9	7,800	2,300	230
Africa	3.2	2.1	66%	0.6	0.6	2,100	1,300	130
South and Central America	6.0	3.5	58%	0.9	0.5	4,800	3,100	310
Total	**101.2**	**83.3**	**82%**	-	-	**117,900**	**51,200**	**5,120**

Table 1. Reliability spend estimates worldwide by region
**Commonwealth of Independent States*
***Excluding China and India*

HOW CAN YOU HAVE GREATER THAN 100% UTILIZATION?

Table 1 shows India having a utilization of 102% in 2019. It is possible that India's total capacity is understated, either because the data does not account for the most recent plant upgrades or a plant has underreported its own capacity. It is also possible India's production level is overstated, either through a reporting mistake or if Indian refiners sold product from storage on top of nearly full refinery runs. Regardless, the relevant observation is that in 2019, Indian refiners operated at or near full capacity, a level that significantly exceeds any other region around the world.

Total worldwide refining capacity is around 101 million barrels per day (bbl/d). In 2019, the world's refineries had a combined throughput of 83 million bbl/d, meaning they were 82% utilized. Utilization is the fraction of the maximum throughput that the plant actually runs. For example, if, during a 365-day window, a particular refinery only chooses to run the plant on 320 days, its utilization rate is 88% (=320/365).

In a perfect world, Table 1 would include availability instead of utilization. Utilization only measures the facility's actual output relative to the facility's nameplate capacity. There are many economic reasons why refinery operators may choose not to run their plants or may run their plants at reduced capacities. So, if one refinery is more heavily utilized than another, it still might not be more efficiently operated or maintained. There may be economic circumstances unique to one of the plants that explains the difference in utilization. Availability, on the other hand, measures the fraction of time a facility could run, relative to the total time it could have run (again, its nameplate capacity). Then, differing economic circumstances are immaterial. Whether a facility runs or not only depends on the ability of the operators to keep their facility in working order. That's why, all else equal, we'd strongly prefer to use availability as our reliability metric. Unfortunately, availability is only sporadically reported while utilization is much more widely reported. A refinery is available when it is able to run, regardless of it actually running at the moment or not. Availability is the fraction of a given window of time in which the plant is able to run. For example, if, during a 365-day window, the plant is available 350 days, then the plant's availability is 96% (=350/365).

When might a refinery be available, but not utilized? One scenario is when the expected economic returns of running the facility fall below a required breakeven threshold. The plant operators may choose to temporarily idle the plant, waiting for conditions to improve. In this scenario, the plant is available, but due to economic reasons, it is not utilized.

In the US, where all refineries are privately held, refiners will often make decisions to lower utilization to maximize economic return. In overseas facilities, where refineries are owned all or in part by government entities, this action will occur much less frequently since those refineries do not have the same financial pressure as US refineries. Regardless, since availability is not public information for most refineries, utilization should be used as a proxy when evaluating the refining segment on a regional or global level. Beyond capacity, throughput, and utilization, we included two cost indices in Table 1, one for energy and one for people. These indices communicate the cost of energy and labor on a regional basis, normalized to 1.0 for the US. In other words, we estimate that Chinese refiners pay approximately 10% less for input energy and 40% less for labor than their US counterparts.

Costs of energy and labor are determined starting with public information on differences, then modeled based on known adjustments. For energy, this is because, in countries outside of the US, Canada, and Europe, government entities subsidize energy costs dramatically. As for labor, differentials in average labor rates between two countries are not as dramatic when compared across specialized sectors.

For example, in India, the average labor rate is less than 20% of the US average labor rate, yet the cost of a person skilled in running a refinery in India is closer to 60% of their US counterparts when averaging in the cost of personnel brought in from outside the country to help design and operate the facility.

Overall, the main conclusion from Table 1 is that the US, Canada, and India appear to have the most reliable operating portfolios.

US Reliability Spend Patterns

18.8
TOTAL CAPACITY (BBL/D)

17.0
2019 THROUGHPUT (BBL/D)

90%
UTILIZATION

$27.6B
OPERATING COST

$10.1B
ESTIMATED RELIABILITY SPEND

The average cost of reliability for US refiners is on the lower end of the spectrum at $1.60 per barrel of throughput, likely due to the “fast follower” dynamic and competitive environment.

US RELIABILITY SPEND PATTERNS

As stated above, we estimate that US refiners spend $10.1 billion annually on reliability-related activities. At a throughput of 17 million barrels per day, we estimate US refiners have an average cost of reliability around $1.60 per barrel of throughput. In terms of utilization, the US is at 90%, second to India at 102%.

Figure 2 shows reliability spend intensity for seven publicly traded US independent refiners, along with results for four **international oil companies** with substantial refining presence in the US. The chart shows corporate results for three years – 2017, 2018, and 2019 – with estimated reliability spend per barrel of throughput on the horizontal axis and average throughput on the vertical axis.

> An **INTERNATIONAL OIL COMPANY** is a privately-owned company with substantial business presence in multiple countries, for which petroleum refining typically represents 20% or more of total revenue.

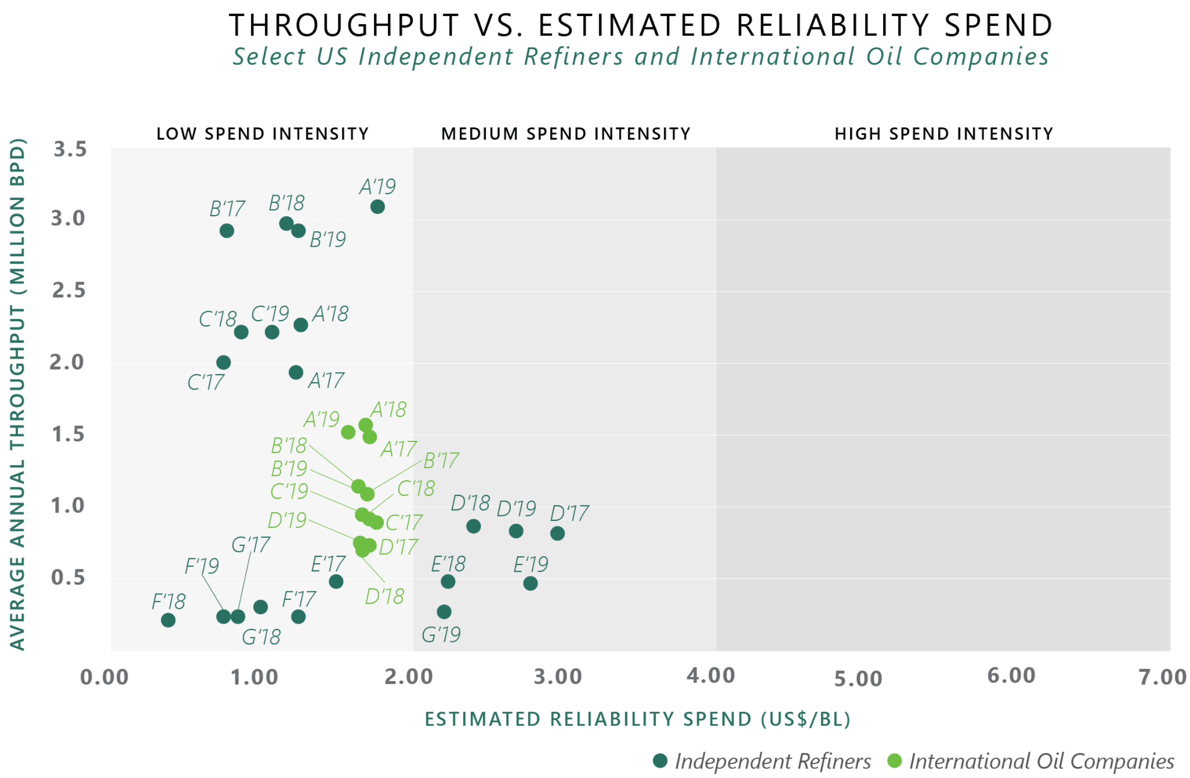


Figure 2. Estimated reliability spend vs. throughput, select US independent refiners and international oil companies

The refiners on the low end of the spectrum typically spend between $0.50 and $1.00 per barrel on their reliability program. We see another cluster of refiners with reliability spend around $1.50 per barrel. In the US, we do not see any refiners with average reliability spend in excess of $4.00 per barrel, which we label high spend intensity to indicate spend well above average levels. In the next section, we will explore a region of the world where we do find refiners with these considerably higher spend intensities.

Figure 2 shows that different classes of refiners can occupy all tiers on the spectrum of reliability spend -

with independents and integrated majors on both the low end and the high end of reliability spending. Optimized reliability programs are not strictly the domain of the largest, most deeply capitalized players. Any refiner at any scale can design and implement a reliability program than can drive their unit spend down, while generating additional uptime and productivity, all at best-in-class levels. Scale is not necessary.

Reliability spend is only half the equation. The other half is reliability outcomes. The data we study in this report does not directly tell us about reliability performance. In any given year, a refinery may spend considerably more or less than the average, largely because reliability activities can be large and difficult to distribute evenly in time. Still, our experience shows that long term, the most efficient refiners can consistently spend less than their average peers to achieve better than average reliability outcomes.

As mentioned, refinery management teams can choose to spend very little in a given year. If the refinery has a suboptimal reliability program, however, these deferred costs will reappear with exaggerated impact shortly thereafter. With an optimized reliability program, refiners can consistently spend less than their peers, year in and year out. Refiners achieve this result by properly quantifying and assessing risk and deploying their limited reliability resources accordingly.

In the US, we see most refiners clustering between $1.00 and $2.00 per barrel in reliability spend. This result is consistent with the "fast follower" dynamic typical in the US, where refiners often agree on best practice. Therefore, if one operator discovers a best practice, it will catalog its results, and the success becomes widely known across the region. Since refining margins are often relatively small, competing management teams are quick to implement new practices or the ones that work best in their portfolio. As a result, we see comparatively little dispersion in estimated reliability spend among US refiners versus the rest of the globe.

However, within the US market itself, this range is noteworthy. With operating margins for many refiners ranging between $3.00 and $6.00 per barrel, a difference of $1.00 per barrel in reliability spend is separating the best performers from the middle of the pack. As a result, market capitalization (total company value) per barrel of oil refined for US independent refining companies is inversely correlated to how much they invest in reliability to achieve comparative utilization.

Asia Pacific Reliability Spend Patterns

Excluding China and India

14.3

TOTAL CAPACITY (BBL/D)

11.7

2019 THROUGHPUT (BBL/D)

82%

UTILIZATION

$20.4B

OPERATING COST

$10.7B

ESTIMATED RELIABILITY SPEND

Asia Pacific, excluding China and India, spends 50% more on reliability-focused activities than the US.

ASIA PACIFIC RELIABILITY SPEND PATTERNS

For the purposes of this section, “Asia Pacific” does not include China or India. In Asia Pacific, we estimate refiners spend about $2.50 per barrel of throughput on reliability-related activities, which is nearly 50% more than we see in the US. We also estimate that Asia Pacific refiners spend $10.7 billion in areas impacting reliability, which is $600 million more than US refiners spend collectively.

Figure 3 shows reliability spend intensity for the 10 largest refiners by throughput in Asia Pacific. The chart shows enterprise-level results for the years 2017 and 2018, with estimated reliability spend per barrel of throughput on the horizontal axis and average throughput on the vertical axis.

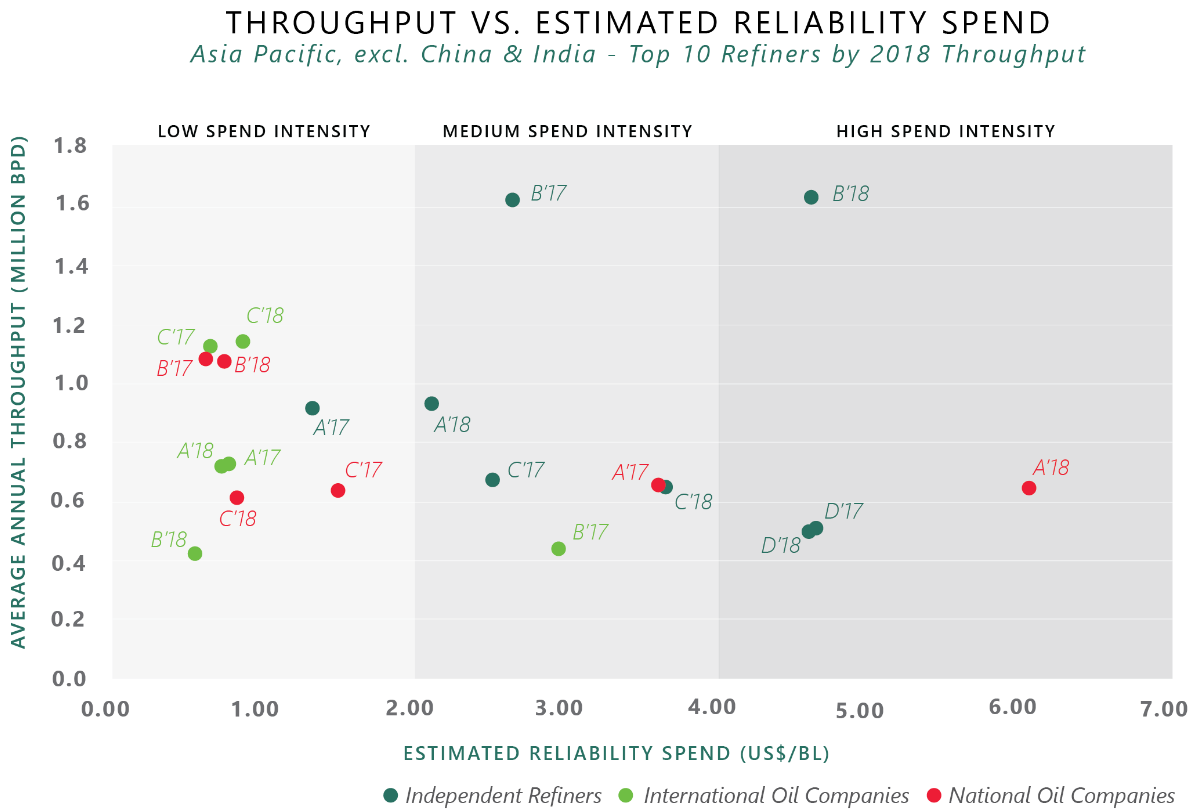


Figure 3. Estimated reliability spend vs. throughput, top 10 refiners in Asia Pacific, excluding China and India, by 2018 throughput

In addition to having larger average spend, Asia Pacific refiners also show much more variation in their spending patterns than the US. In the US, we identified a tight cluster of operators around the average spend level while in the Asia Pacific region, many more of the top 20 refiners spend in excess of $3.00 per barrel.

In the US reliability spend patterns section, we described the tight clustering as a result of the “fast follower” phenomenon, where best practices quickly disseminate through the refining community. In Asia Pacific, many refineries belong to national oil companies (NOCs). The competitive dynamics for these refiners are different than those for US refiners. In the US, many of the largest refiners are publicly traded and compete actively against each other for the attention of potential shareholders. These market forces motivate the quick identification and adoption of best practices, which is an important reason we see clustering of US refiners around relatively low average reliability spend levels.

As we saw with the US refiners, no class of refiners has a monopoly on optimized reliability spend. We see both international oil companies and national oil companies in Asia Pacific with reliability spend levels below $1.50 per barrel of throughput. A refiner does not need scale or private ownership to drive unit reliability spend down to acceptable levels. Again, if facilities are able to gather the right data, analyze that data, and follow their analysis with the right interventions, then they can yield exceptional results.

China & India Reliability Spend Patterns

21.2
TOTAL CAPACITY (BBL/D)

18.5
2019 THROUGHPUT (BBL/D)

87%
UTILIZATION

$24.8B
OPERATING COST

$15.3B
ESTIMATED RELIABILITY SPEND

The scale of refining in China and India is 21% of the world's refining capacity, meaning the reliability improvement opportunity is largest here.

CHINA AND INDIA RELIABILITY SPEND PATTERNS

We estimate that refiners from China and India spend approximately $2.30 per barrel of throughput, directly between the amount spent by US and remaining Asia Pacific refiners. In other words, Chinese and Indian refiners spend about 40% more than their US counterparts, but around 10% less than their peers across the rest of the Asia Pacific region, which is why we have broken out China and India from the rest of Asia Pacific.

The scale of refining in China and India is 13% larger than in the US. China and India combine for a throughput of 21.2 million barrels per day, or 21% of the world's refining capacity. These regions spend approximately $15.3 billion annually in areas impacting reliability, over 50% more than the $10.1 billion in spend we estimate for the US. As a result, the reliability improvement opportunity is largest in China and India, when you combine the scale of their refining with considerable increase in average spend per barrel across Asia Pacific.

Figure 4 shows reliability spend intensity for the 10 largest refiners by throughput in China and India. The chart shows enterprise-level results for the years 2017 and 2018, with estimated reliability spend per barrel of throughput on the horizontal axis and average throughput on the vertical axis.

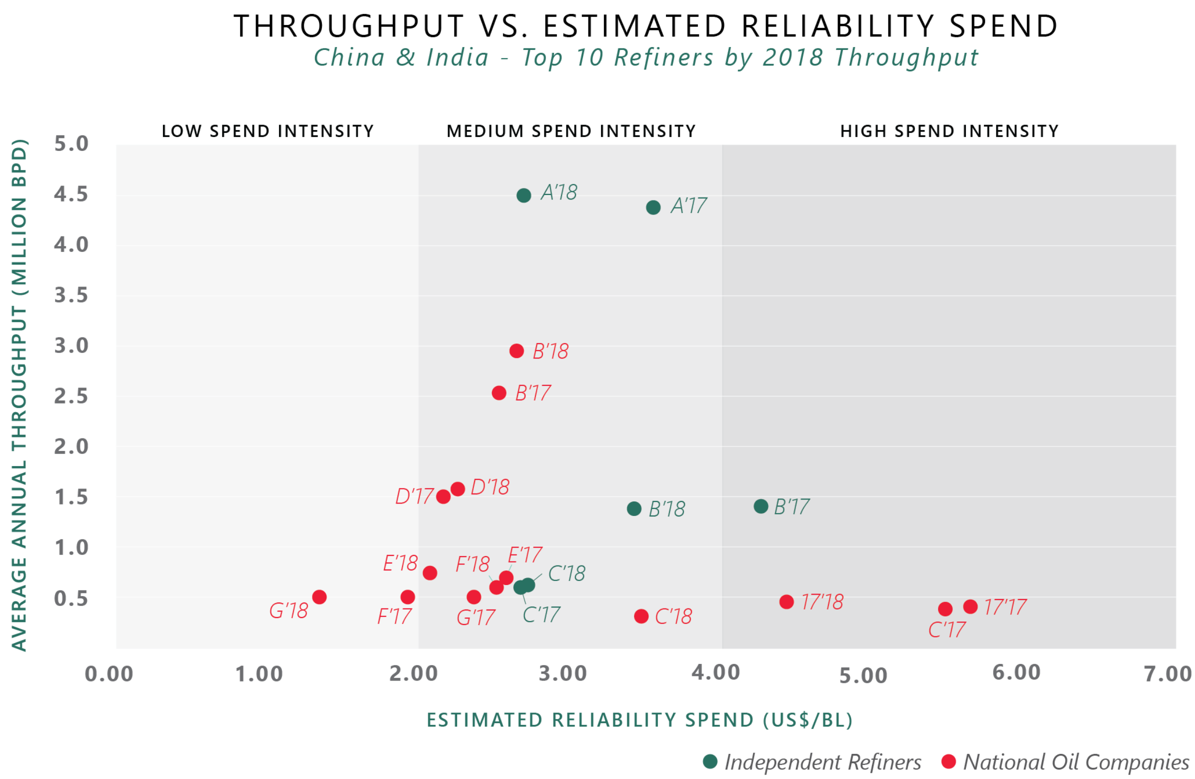


Figure 4. Estimated reliability spend vs. throughput, top 10 refiners in China by 2018 throughput

One similarity between China and India and the rest of Asia Pacific is the wide range of estimated reliability spend. There is not quite as much variability in China and India compared to the rest of Asia Pacific. In China and India, the lowest spend range is between $1.00-2.00/bbl. In the rest of Asia Pacific, we see several refiners in the sub-$1.00/bbl range. Likewise, in China and India, the most intense reliability spending is between $5.00-6.00/bbl. However, in the rest of Asia Pacific, we see spending in excess of $6.00/bbl.

These results from China and India give us more confidence that the differences between what we saw in the US and Asia Pacific are not exclusively the result of scale. In other words, we do not see better average performance in the US strictly because refiners are larger and presumably enjoy more attractive economies of scale. The largest refiners in China and India have more throughput than the largest US refiners. Even with the added scale, we still see reliability spend intensity in the $2.50-3.50/bbl range in China and India, well in excess of the $1.00-2.00/bbl range we saw for the largest US refiners. If scale had an outsized impact on reliability spend, the largest refiners in China and India would have lower reliability spend levels than we estimate.

One big difference between the US and all of Asia Pacific, including China and India, is refinery utilization. The US has utilization of 90%, while all of Asia Pacific has a utilization of 86%. We described earlier that we use utilization as a proxy for availability, which would be our preferred measure of facility-level reliability.

US refiners have achieved higher utilization levels than their Asia Pacific peers while spending less on reliability-focused efforts. We postulate several reasons for this phenomenon, which will be discussed in the conclusion section of this report. One fundamental dynamic is that most US refining capacity is controlled by publicly traded entities. The existence and future success of these entities are tied solely to their operational and financial performance, which is continuously reported. State-owned enterprises may serve other functions, e.g., supply jobs to the local population and meeting national security interests. Closely held private entities do not face the same scrutiny as publicly traded players, which explains why US refiners are more strongly incentivized to optimize portfolio reliability, and why we see such relatively low average spend levels across the US refining sector.

Europe Reliability Spend Patterns

15.7
TOTAL CAPACITY (BBL/D)

12.7
2019 THROUGHPUT (BBL/D)

81%
UTILIZATION

$21.2B
OPERATING COST

$5.7B
ESTIMATED RELIABILITY SPEND

European refiners spend nearly 25% less per barrel of throughput on reliability-focused activities compared to the US due to its highly-regulated market.

EUROPE RELIABILITY SPEND PATTERNS

According to Figure 1, European refiners spend around $1.20 per barrel of throughput on reliability-focused activities, or nearly 25% below the spend levels for US refiners. Figure 5 shows reliability spend intensity for the 10 largest refiners in Europe by throughput. The chart shows enterprise-level results for the years 2017 and 2018, with estimated reliability spend per barrel of throughput on the horizontal axis and average throughput on the vertical axis.

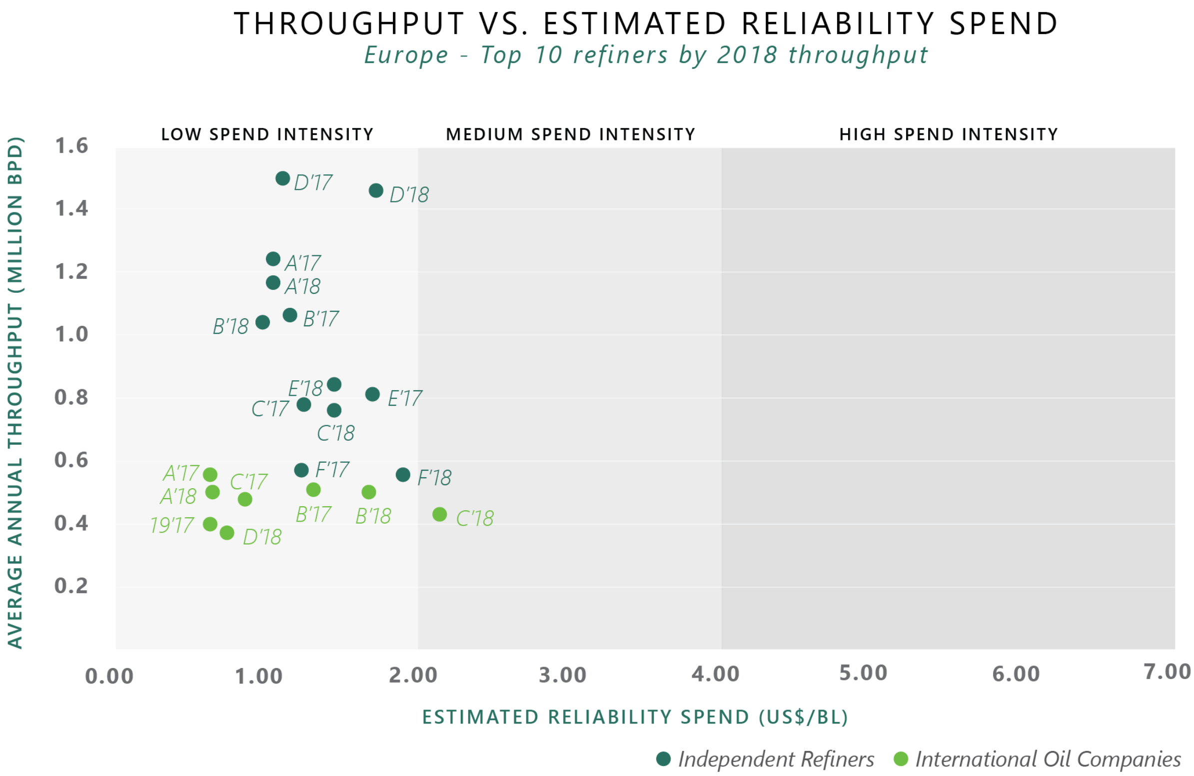


Figure 5. Estimated reliability spend vs. throughput, top 10 refiners in Europe by 2018 throughput

The lightest spend levels we see for European refiners is around $0.60 per barrel of throughput. The heaviest spend level is barely over $2.00 per barrel, well below the high end of $5.00-6.00 per barrel that we saw for some Asia Pacific refiners. Not only do European refiners, on average, spend considerably less on reliability-focused activities than their global peers, but they cluster near the low end of the spend spectrum. One conclusion may be that European refiners take the idea of lean reliability spending even further than what we see in the US. After all, the largest European refiners are publicly traded, similar to their US peers, which motivates the continued, aggressive pursuit of operational efficiencies. The European refining sector is a mature, highly regulated market, which has given refiners the time and the regulatory incentives to optimize their reliability. In addition, these refineries have much lower complexity than their US counterparts and have much lower (on average) utilization.

The range of throughput that we see in Europe is similar to what we have in Asia Pacific, excluding China and India. This phenomenon again shows that scale does not have an outsized impact on utilization and reliability spend, as refiners in Europe spend considerably less than their same-sized peers in the Asia Pacific region. European refiners had a utilization of 81%, in line with the global average, but notably below the 86% utilization for Asia Pacific, including China and India, and the 90% utilization for the US. While European refiners spend less on reliability, they also run their refineries slightly less than we see elsewhere in the world. Therefore, many European refineries are leveraging a small geographic advantage in the local market, spending less on reliability, and accepting lower utilization as a result. The driving forces behind slightly sub-par European utilization levels will be more thoroughly investigated in upcoming reports.

TRENDS

1. The refining market will improve, but will still face challenges

Four countries – the US, China, Russia, and India – account for 39 million barrels of the world's capacity. Furthermore, CIS-Russia is planning to add roughly 1 million barrels per day (mbpd) of capacity,[12] and China is adding an estimated 1 to 2 mbpd over the next few years.[13] Meanwhile, refining operations in Mexico, Europe, and South America are all expected to decline. Based on these estimates, the US, China, Russia, and India could control half of the total global refining capacity by 2025.

Data from Wood Mackenzie shows the most profitable refining operations in the world are in North America (Figure 6). We use earnings before interest, taxes, depreciation, and amortization (EBITDA) as our preferred measure of profitability for these purposes. The chart shows EBITDA versus utilization by global region, with utilization on the horizontal axis and EBITDA per barrel of throughput on the vertical axis.

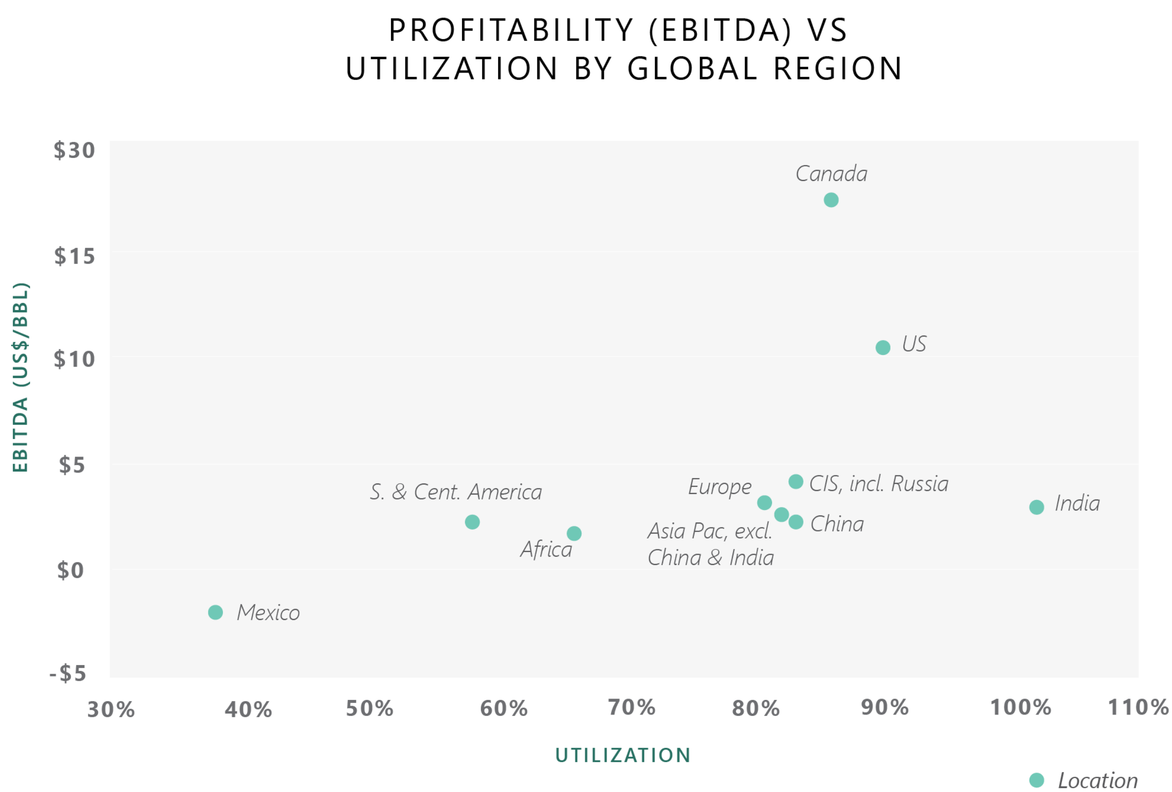


Figure 6. Profitability (EBITDA) vs. utilization by global region

The chart also shows a relationship between utilization and profitability. Unsurprisingly, the two most profitable global regions – the US and Canada – have utilization levels of 90% and 86%, respectively, which are above the global average level of 82%. Mexico is the least profitable global region and has the lowest utilization at 38%.

From the low point of 2020, we expect that refining margins will generally improve in the short run. Three things will drive this upward pressure: fuel demand returning as countries pull out of government shutdowns, cheap feedstocks from excess crude oil production, and lower total refining capacity due to shutdown of some facilities.

The market, however, will continue to face significant headwinds. For example, further capacity growth in China will weigh against the pricing of finished products. Additionally, the accelerating presence of electric vehicles will weaken liquid fuel demand. Regulatory pressures will keep growing, placing a lid on potential future margin expansion and slowing upstream production growth will buoy feedstock prices and compress margins. In the US, natural gas prices are edging higher, which may reduce one of the US refining sector's largest structural advantages: the cost of energy. These pressures may be offset by announcements by companies like BP and Shell who say they are exiting refining, but we do not anticipate this to have an impact for several years.[14]

2. Operational improvements are coming

In the face of adverse market forces, companies are pushing harder than they have in decades to make operational improvements while simultaneously cutting costs. Chevron, BP, Shell, and Exxon have all announced major cost cutting initiatives, including reductions in capital spend, operating expenses, and staffing levels.[15,16,17,18] At the same time, virtually every major oil and gas company is investing heavily in strategic improvements, especially **Digital Transformation**. We estimate that oil and gas companies – including exploration and production, midstream operations, and downstream facilities – are planning to spend $20 billion over the next five years on these projects alone. While there are several challenges in achieving operating improvement – especially in digital infrastructure – the potential for such improvement and cost optimization is substantial.

> **DIGITAL TRANSFORMATION** is the ongoing evolution where businesses are increasingly measuring and analyzing their own performance through the collection of data in digital form.

3. The pace of change is accelerating

For the first time in modern history, oil and gas majors began to diverge dramatically in their forecast of energy markets in 2020. BP stated that the world oil demand may have peaked in 2019.[19] In addition, the company announced that it was embarking on a plan to exit the oil business, with intentions to divest assets and use the capital to invest in alternatives. Environmental, Social, and Governance (ESG) pressure has been a dominant topic for the past few years, especially in the oil and gas industry. When it comes to refining, that pressure continues to mount. A difficult economic environment in 2020 forced virtually every refiner to make massive cuts in spending, and sparked questions as to the stability of some of the facilities. In response, companies have announced plans to make aggressive changes to operations, including optimizing costs and working to improve facility performance. For example, at the 2020 Security Analyst Meeting, Mark Nelson, an Executive Vice President at Chevron, stated plainly that their downstream segment has slipped out of the premier operator spot, and that he expected the company to regain that spot soon in part through a focus on improved reliability.[20] In an industry with a tradition of very slow changes, the future leaders will most likely achieve that spot due to the pace at which they evolve.

INSIGHTS

While much of the data in this report is gathered from a corporate or regional level and some broad assumptions are made, there are still very striking conclusions about the relationship between reliability spend, reliable performance, and profitability. Due to the comprehensive nature of the data available in refining, the aggregate results provide insights into individual facility decisions.

1. Reliable operation is the largest indicator of profitable operation

Globally, raw product and material costs (crude, natural gas, and equipment) represent about 90% of a refinery's spend. Most of these costs are based on commodities and may vary temporarily due to geographic or contractual strategies, but will usually equalize over time. For example, in 2017, some US refineries were able to purchase crude at a discount due to proximity to the Permian Basin, but eventually pipeline infrastructure removed these advantages almost completely. Since most of these advantages are temporary, the opportunity to be profitable is disproportionately driven by the last 10%, of which 4-7% is operating costs. The data here revealed that not only did the most profitable operators have the highest utilization and availability rates, but they also had the lowest levels of reliability spend. In other words, if the plant can optimize its investment in sustaining operations, and get the most runtimes for the least money, then they can move from one of the least profitable facilities to one of the most profitable.

2. All reliability spend is not created equal

There are some large disparities in spend on maintenance and turnarounds across the sector, which do not translate into the same levels of reliability. For example, Valero spends notably less on reliability, yet has some of the highest reliability levels, with 97% mechanical availability.[21] The large, integrated oil companies have an average of 94 to 95% mechanical availability yet spend 30% more on maintenance and turnarounds. Figure 7 compares the profitability of all the refining companies included in this study, relative to the amount they spend on reliability.

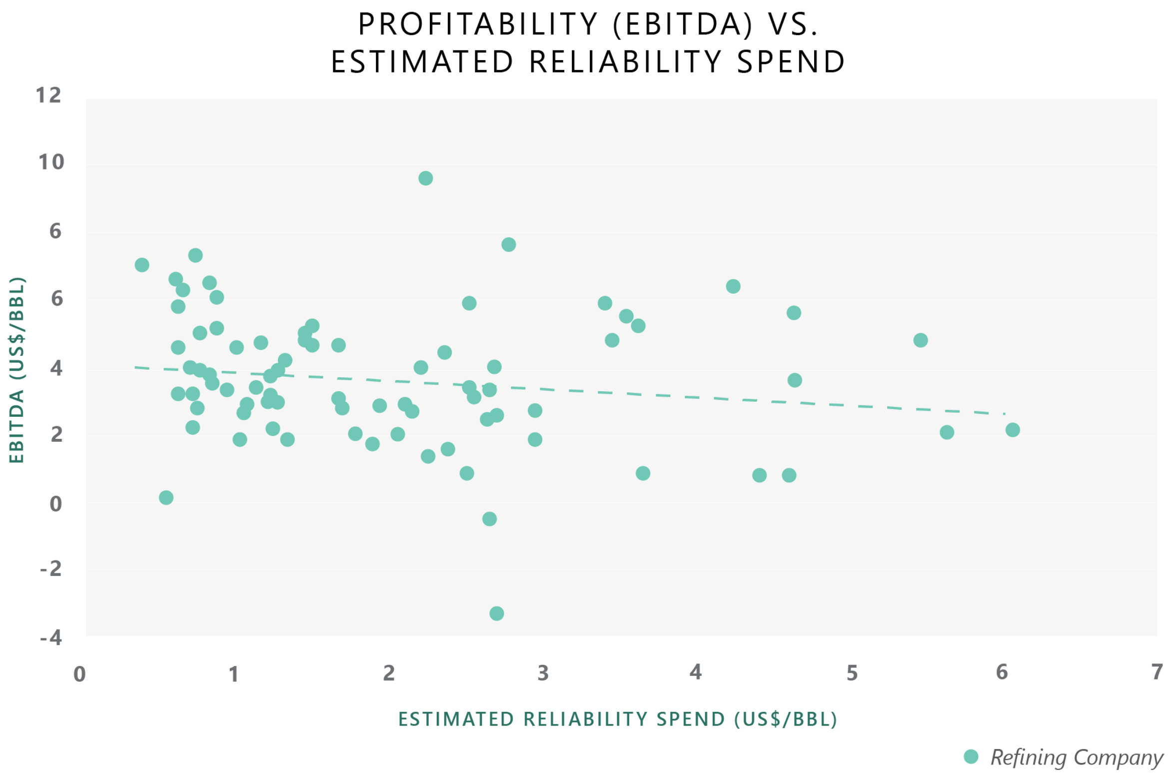


Figure 7. Profitability (EBITDA) versus estimated reliability spend

One would expect that profitability and reliability would move somewhat proportionately. After all, the refineries with the highest per-barrel operating margins should have the greatest return on reliability spend. However, the data, while only loosely correlated, shows the opposite. In general, the more money that refiners spend on reliability, the less profitable they become.

3. North American facilities are providing a roadmap for designing and executing optimal reliability programs

Refiners in US and Canada represent some of the most profitable in industry due to a number of factors, such as complexity (ability to run various blends and produce a range of products), lower energy costs, geographic proximity to both supply (crudes), and demand. However, these refiners have other disadvantages, such as high transportation costs, high labor costs, and higher liability/risk profiles due to western social expectations. From our analysis, the primary differentiator is the combination of lower per barrel spend on reliability and the higher utilization. In other words, the North American refineries are, on average, getting more throughput from their investments. This differentiator can be replicated as the US refiners publish annual economic data and annual results are tracked in great detail. As other regions attempt to obtain the same balance of investment and performance, the practices adopted by the US leaders provide good examples.

4. Two US independent refiners have demonstrated clear differentiation from the rest of the refining segment

Evaluating individual companies or facilities on a single year performance will not often lead to accurate results. Timing of planned turnarounds, regional market conditions, or opportune crude purchases can easily skew single quarter or annual numbers. However, when looking over the years 2017, 2018, and 2019, two US independent refiners have clearly set themselves apart. Our estimates are that these two companies spend some of the lowest amounts on reliability yet achieve some of the highest levels of productivity from their facilities. The companies' annual reports have referenced their strategic investment in upgrades and focus on operational excellence, motivating other global refiners to rethink their approach to reliability.

From our analyses and our experts' experience, between 10% and 30% of this spend is wasted, meaning it does not improve reliability.

CONCLUSION

In this report, we shared results from our internal models describing the reliability performance of refiners across the world. We estimate that global refiners spend over $50 billion annually on reliability-focused activities, primarily between routine maintenance efforts and turnaround programs. From our analyses and our experts' experience, between 10% and 30% of this spend is wasted, meaning it does not improve reliability. In fact, in some instances, we believe some of this spend may actually have a detrimental impact on performance, weighing even further against profitability. In this sense, suboptimal approaches to reliability cost refiners between $5 and $15 billion annually worldwide.

The most profitable operators are found in North America, specifically between the United States and Canada. At $1.20 per barrel of throughput, European refiners spend the least on reliability-focused activities, while achieving utilization levels in line with the global average. The refiners with the greatest intensity of reliability spending are found in the Asia Pacific region, with some refiners spending in excess of $5.00 per barrel on such activities.

While North America is the home of the most profitable refiners, we find low-cost refiners in many regions of the world. These refiners, who are able to sustain their operations with relatively low spend levels on reliability-related activities, run the gamut. They vary between low throughput or high throughput, regionally concentrated independents, national oil companies, or international oil companies.

Throughout the markets and companies studied, there is a large disparity between the reliability spend, reliability performance, and profitable operation. We conclude that this disparity is driven by two primary factors. First, reliability is a long-term investment. Refiners must invest money today to get reliability return over a multi-year span. As such, there may be some correlation between current spend and current performance. While our analysis covered multiple years, there still can be some refiners who are reaping the rewards of prior year investments in reliability. The companies who did not make those investments historically are therefore catching up. The second driver is an inefficient use of reliability investments by some refiners compared with others. As discussed in Insights, there is an inverse correlation between reliability spend and profitability. However, in some facilities, spending on maintenance, turnaround, and inspection is driven heavily by personnel and decision practices that have been in place for decades without change. The lack of evolution translates into significant spend with diminishing return. By comparing the range of utilization to the range of reliability spend, we conclude that between 10% and 30% of industry spend on reliability-related initiatives are wasted.

The good news is that a world-class reliability program is available to all refiners. The challenge is concentrating resources on high-value activities, while avoiding or delaying the lower-value activities that attract too many resources from the average refiner. In our experience, consistent systems using data-focused analysis is the key differentiator. Companies with the most efficient reliability spend tend to be using the most quantitative analysis processes to inform strategies. Those that are using processes that are heavily dependent on people alone tend to spend more and get lower utilization. In particular, the industry trends to apply data from across the facility, covering the spectrum of operating assets, is at the forefront of the refining sector.

Given the disparity in reliability spend and utilization across company size, ownership, and geographic region, it appears that reliability - and therefore sustainability - of facilities is not dependent on any traditional concepts. Rather, it is the commitment of refinery/company leadership to push for program improvements and drive change at a pace deemed uncomfortable to others.

In order to optimize reliability spend and reliable performance to minimize risk and maximize profits, a refinery can do four things:

1. ***Develop consistent, quantitative systems for evaluating system performance***
2. ***Integrate reliability data from a range of sources and assets into single system models to ensure the critical inputs and influences are identified***
3. ***Ensure personnel are adapting their work processes and utilizing these systems effectively to leverage their capabilities***
4. ***Push past traditional decision processes or practices to uncover new opportunities and solutions***

While these items sound simple, they have proven challenging for many refiners. Across the board, those who are doing all four of these appear to have both a lower risk profile and a higher profitability result, validating the premise that reliability is one of the leading indicators of profitable operation.

GLOSSARY

Availability	The fraction of time a facility was in condition to run, relative to the time it could have run (its nameplate capacity)
Blendstock	Any fluid serving as an input to a blending process
Complexity	A measure of the operational intensity of a particular refining process
Constant Dollar Terms	An approach for comparing economic values from different points in time, such that the impact of the time value of money is ignored
Crack Spread	The difference in price between refined product(s) and chosen input(s)
Demand	The amount required for a society to continue to operate in its normal capacity
Digital Transformation	The ongoing evolution where businesses are increasingly measuring and analyzing their own performance through the collection of data in digital form
Globally Fungible Commodities	Commodities as traditionally defined, with the added emphasis that no country or region enjoys any meaningful advantage or suffers any meaningful disadvantage related to the supply, demand, or transportation of the commodities in question
Government Coffers	The financial accounts through which a government may fund a program
Headwinds	Forces acting against the efficacy of an action or outcome
Independent Refiner	A privately-owned company whose primary line of business involves petroleum refining
International Oil Company	A privately-owned company with substantial business presence in multiple countries, for which petroleum refining typically represents 20% or more of total revenue
Lean Manufacturing	An approach to manufacturing that emphasizes the elimination or modification of wasteful or inefficient activities, with the goal of materially improving the quality of final products
Maintenance	Routine activities with the purpose of maintaining the working order of productive assets

GLOSSARY

National Oil Company	A mostly or wholly government-owned company, primarily operating in a single country, for which petroleum refining typically represents 20% or more of total revenue
Operators	Companies, agencies, or institutions whose personnel directly oversee the day to day functions of complex process facilities and make the long-term financial and strategic decisions about the facility future
Reliability	The property where a productive asset is in condition to serve its intended function
Reliability Spend Intensity	A measure of reliability spend on a per unit basis, which, in this report, is often per barrel of throughput
Tailwinds	Forces acting in favor of the efficacy of an action or outcome
Throughput	The volume of liquids processed in a given period of time
Turnarounds	Infrequent, intensive activities aimed at maintaining the working order of productive assets, which often involve taking the assets in question offline in advance of or during the work
Utilization	A fraction whose numerator is the facility's actual output and whose denominator is the facility's nameplate capacity, i.e. its capacity if it was capable of continuously running at 100% throughput

CITATIONS

1 Wood Mackenzie Global Refinery Database
2 https://www.eia.gov/petroleum/data.php#refining
3 https://www.eia.gov/todayinenergy/detail.php?id=44316
4 https://www.reuters.com/article/us-global-oil-refinery-shutdowns-factbox/factbox-oil-refiners-shut-plants-as-demand-losses-seen-continuing-idUSKCN25D0C5
5 https://www.wsj.com/articles/u-s-refiners-embrace-greener-fuels-11597251600
6 BP Statistical Review of World Energy
7 US Energy Information Administration
8 Wood Mackenzie
9 US Securities and Exchange Commission, Company investor relations websites
10 GlobalPetrolPrices.com
11 International Labor Organization
12 https://stratasadvisors.com/Insights/2019/032619-Downstream-Russian-CIS-Refinery-Project-Update-2019
13 https://www.bloomberg.com/news/articles/2020-10-06/china-s-building-new-mega-refineries-just-as-fuel-demand-stalls
14 https://www.argusmedia.com/en/news/2160134-european-majors-put-refining-strategy-in-transition
15 https://chevroncorp.gcs-web.com/news-releases/news-release-details/chevron-outlines-plan-deliver-leading-shareholder-returns
16 https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-details-covid19-response-and-provides-market-update.html
17 https://www.shell.com/media/news-and-media-releases/2020/shell-third-quarter-2020-update-note.html
18 https://corporate.exxonmobil.com/News/Newsroom/News-releases/2020/0407_ExxonMobil-reduces-2020-capex-by-30-percent-cash-opex-by-15-percent
19 https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2020.pdf
20 https://chevroncorp.gcs-web.com/static-files/8b4a3907-677a-4596-aa62-78a296544e8b
21 https://www.valero.com/en-us/Pages/SafetyAndEnvironment.aspx#:~:text=Valero%20refineries%20maintained%20their%20lowest,reliable%20and%20industry%2Dleading%20operations

Over 85% of the world's industries are experiencing difficult markets as the world continues to go through one of the worst economic downturns in history. Roughly one third of the world's economy is directly affected by the reliability of operations. From energy to agriculture and transportation to water, reliability can mean the difference between being an industry leader and bankruptcy.

In this interim report, Pinnacle analysts take data from the oil refining industry and dive into how that key sector is being affected by reliability today. From small independent refiners to large integrated oil companies to state owned refining companies, we dive into the differences across the world. Through this report, we explore key indicators of reliability, identify which companies seem to be leading the pack in reliability optimization, and explain the trends that are driving reliability in this crucial sector.

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