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Refining Trends Part II:
The Golden Age or
The Eye of the Storm
Supply



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Refining Trends: The Golden Age or the Eye of the Storm?

Part II: Supply

Refining margins continue to hover at extraordinary levels, contributing to the historically high pump prices consumers see every day. While some industry executives see a Golden Age in which cyclical downturns are a thing of the past, others are less bullish. In this second installment of our study of the future of the refining sector, we look at drivers of refining margins—and analyze the impact of several supply-side scenarios for the future. How long will the Golden Age last? What would be the impact of new conversion capacity, lighter crude supply, reduced demand, or declining crude prices? Will refining revert to a boom-bust cycle typical of capital-intensive industries? And what should refiners do? Our analysis supports optimism about short- to medium-term economics, but suggests that attractive margins may be difficult to maintain in the long term. Declining crude prices and over-investment in conversion could significantly erode margins. Potential demand destruction and the rise of new fuels could be surprises with negative consequences. While clear growth opportunities exist for refiners in the next two to five years, perpetuating the Golden Age will be impossible

without capital restraint and continued high crude prices. Refiners face crucial strategic choices about the future.

Refining margins reflect the forces of supply and demand. In Part I of this series¹, we looked at three demand scenarios and assessed their potential impact on the refining sector. Each of the scenarios suggested that a significant decline in gasoline demand was possible in the next five to eight years, inspired by high prices, new technology, or regulatory changes. (For an update, see “Demand Scenarios: How Do They Look Now?” on page 12 of this viewpoint). In this installment we turn to supply. We begin with a brief review of how refining margins are set and then evaluate the potential impact of several scenarios on these margins. Two of the scenarios focus on supply, and the third factors in changes in demand inspired by our earlier demand scenarios. Together, they enable us to make a more complete assessment of the staying power of this Golden Age. Finally, we identify a set of strategic choices and “no regret” tactics to help industry executives maneuver through the good times... and avoid the bad.

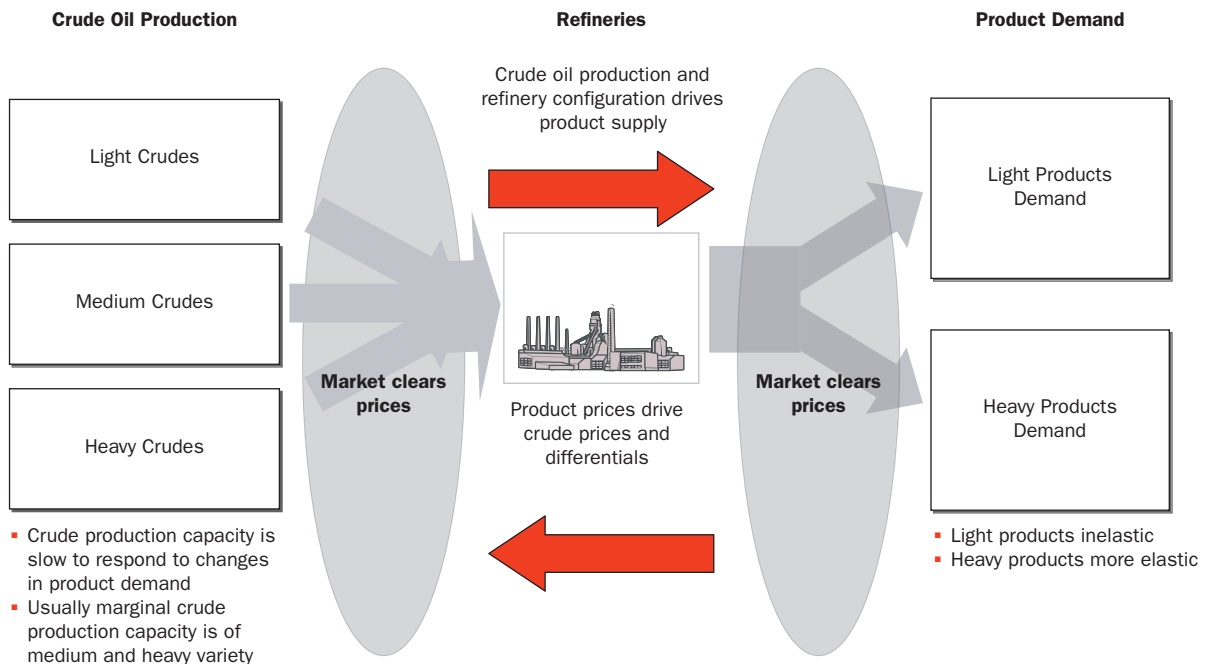
Refining Margins: A Primer

The way that supply and demand affect refining margins is complex (see Exhibit 1, page 2). At a high level,

¹ U.S. Refining Trends: The Golden Age or the Eye of the Storm?, a Booz Allen Hamilton viewpoint by Harry F. Quarls, Robert L. Lukefahr, and Timothy M. Donohue, July 2004. Available from www.boozallen.com.

Exhibit 1

High-level Overview of Oil Market Dynamics



Source: Booz Allen Hamilton

economic activity and consumer choices set demand for refined products. But from the point of view of refiners, not all refined products are equally attractive. Light products like gasoline, for which there is relatively strong and somewhat inelastic demand, offer higher margins than heavy products, such as fuel oil, with weaker demand and price competition from substitutes. All things being equal, refiners want to maximize their output of light products.

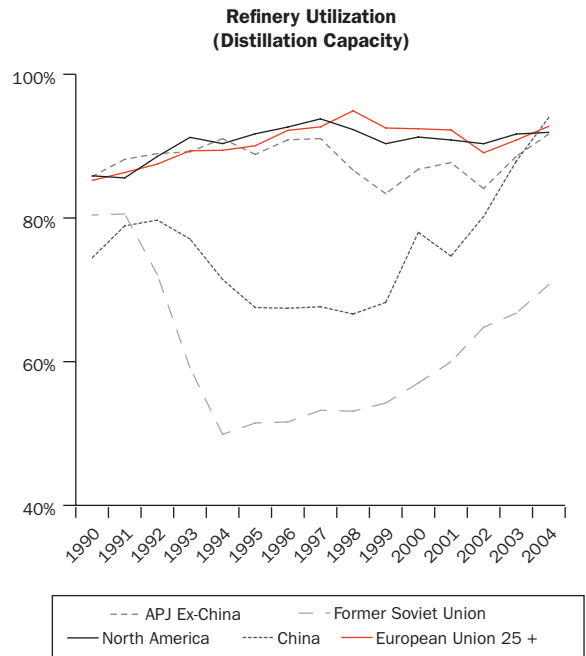
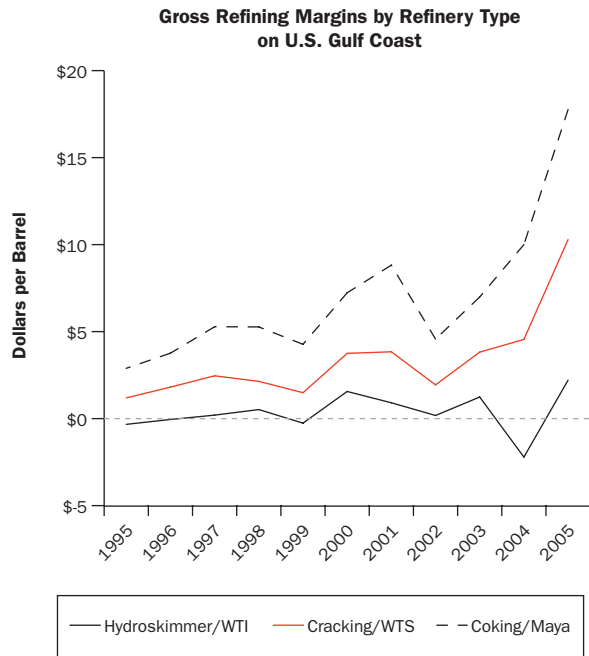
The product slate for any individual refiner and for the market as a whole is determined by the availability of various crude types (which have inherently different product yields) and the capability of their refining assets to convert the various crude types into desired products. Based on their asset capabilities and the relative market price for different grades of crude, refiners must make rational decisions on what mixture of inputs will enable them to satisfy demand and maximize their margins. The fact that the quality of crude production does not respond to changes in refined-products demand only exacerbates the optimization challenge for refiners.

If we want to determine how long today's extraordinary margins will persist, we need to know what drives them. While much of this discussion will be familiar to many readers, it provides an important foundation for the scenarios that follow.

Let's start with two observations about margins and prices since 2003, the advent of the Golden Age. The first observation reconfirms what is well known in the industry: Not all refineries are created equal. Refineries can be grouped in three types that differ in the inputs they use, the complexity of their operations, the outputs they produce, and the economic results they deliver. As Exhibit 2, page 3 illustrates, all the margin gains in the industry have accrued to the medium and high conversion refiners, those capable of running the heavier, higher sulfur, less expensive crudes while still producing the lightest, most valuable product mix. In contrast, hydroskimmers—the least complex refiners, which require the most expensive crude to create the lowest-value product mix—continue to generate little or no

Exhibit 2

Hydroskimming Margins Equal Zero



Source: PLATTS; Booz Allen Hamilton

margin. This is in spite of large increases in overall utilization, particularly for Asian refiners. Hydroskimming capacity (either as refineries or the marginal capacity inside a more complex refinery) has been left out of the Golden Age.

The second observation is that resid (fuel oil) prices have disconnected from crude prices since 2003 (see Exhibit 3, page 4). We believe this is due to the substitutability for much of fuel oil demand by other energy sources. In China and the United States, as much as 70 percent of fuel oil is used for power generation (including that in C&I settings). These applications have potential natural gas and coal alternatives—which limits the price consumers are willing to pay for fuel oil. As fuel oil supplies have increased with higher refinery utilization and greater light product demand, they must be priced in the market at substantial discounts to ever-increasing crude price in order to be competitive against alternative fuels.

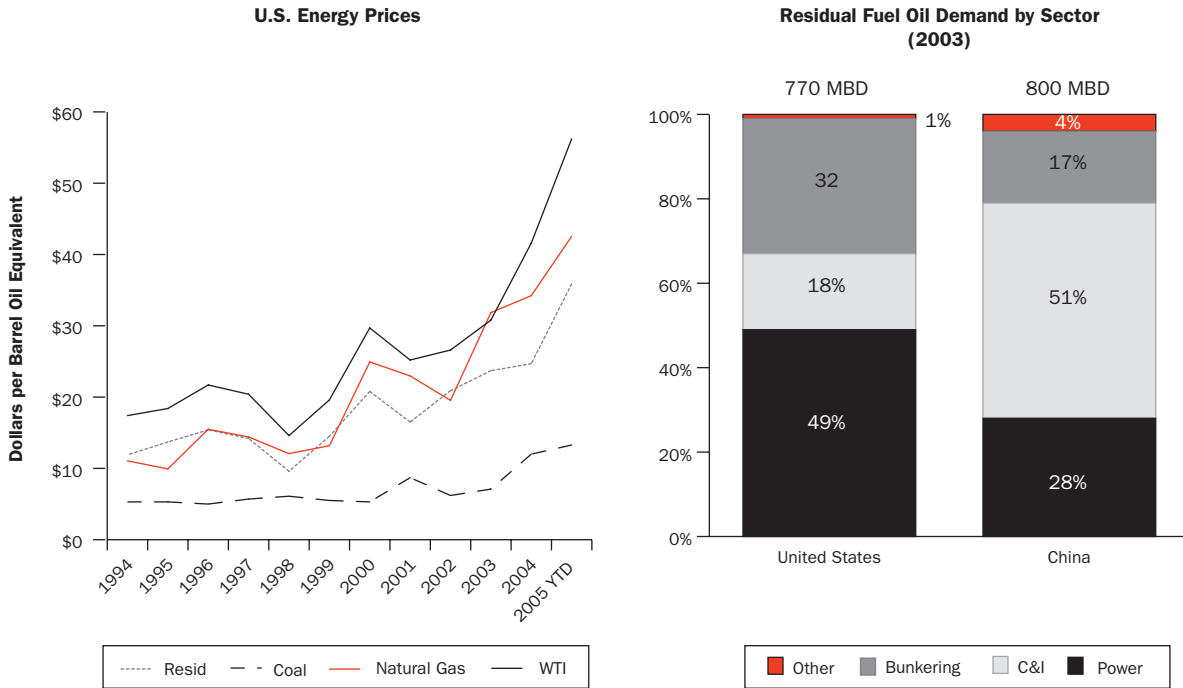
These two factors—that margins for hydroskimmers running light sweet crude are zero, and prices for

resid are set by substitutes—combine to dictate price equilibrium. Price substitution from competing fuels determines the difference between heavy and light products under any crude pricing regime. Furthermore, the price differential for light and heavy products sets the light/heavy crude price differential under any light crude price scenario, since again, hydroskimmers or spare distillation capacity in general deliver zero margins. Faced with limited available conversion capacity, refiners must decide which crude to put through their remaining hydroskimming capacity. The market sets the light/heavy differential at the level at which the marginal refiner is indifferent to distilling light or heavy crude. Using typical distillation yields for light and heavy crudes as well as actual refined product prices, we modeled the indifference point going back ten years. This model closely correlates with actual light/heavy crude price differentials (see Exhibit 4, page 4).

Crude input costs represent the largest proportion of refined product costs. As a result, increasing light/heavy

Exhibit 3

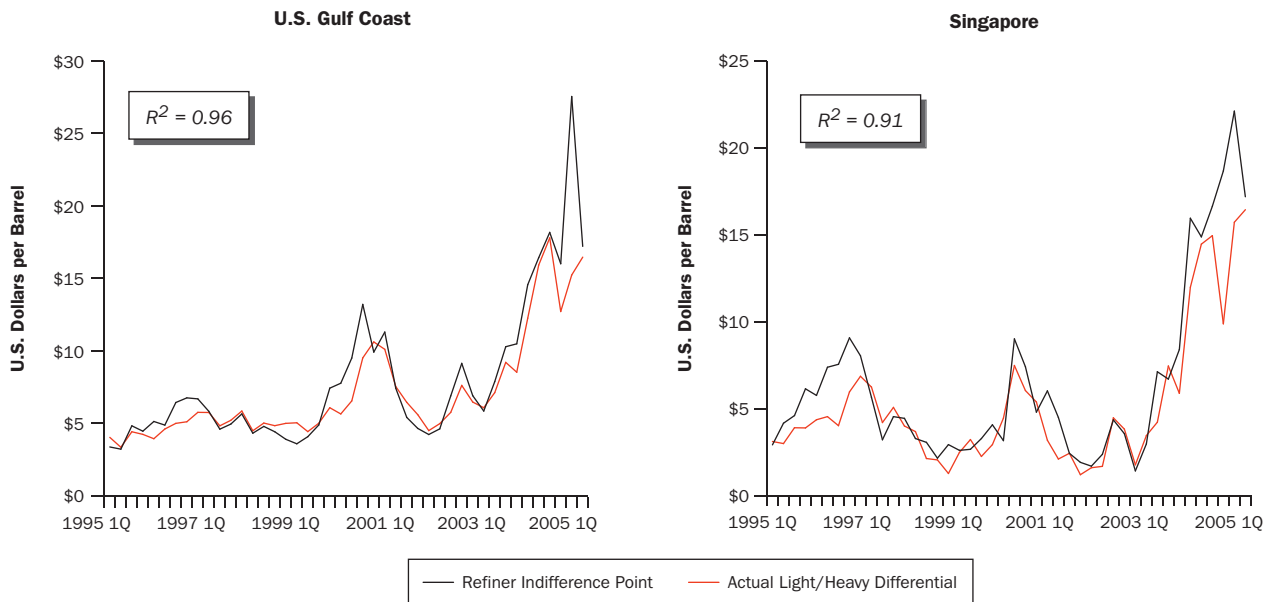
Fuel Oil Prices Disconnect from Crude in Face of Substitutes



Source: PLATTS; Booz Allen Hamilton

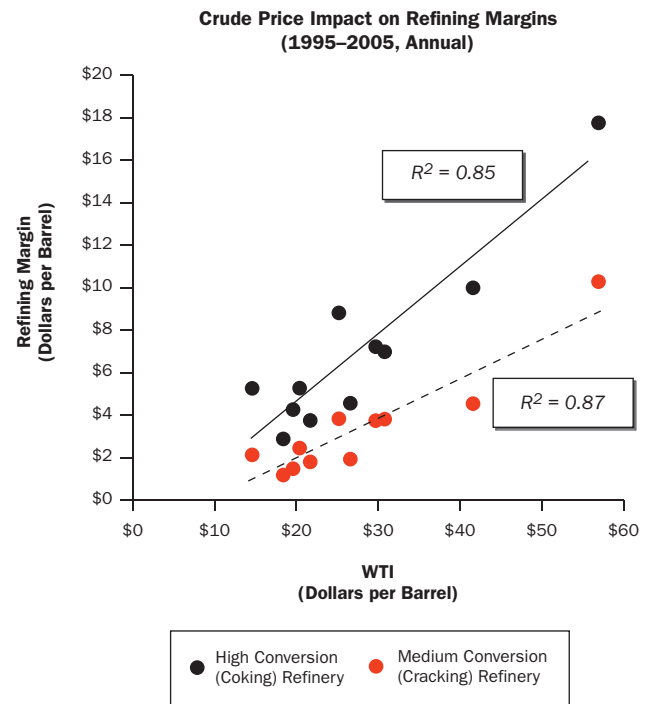
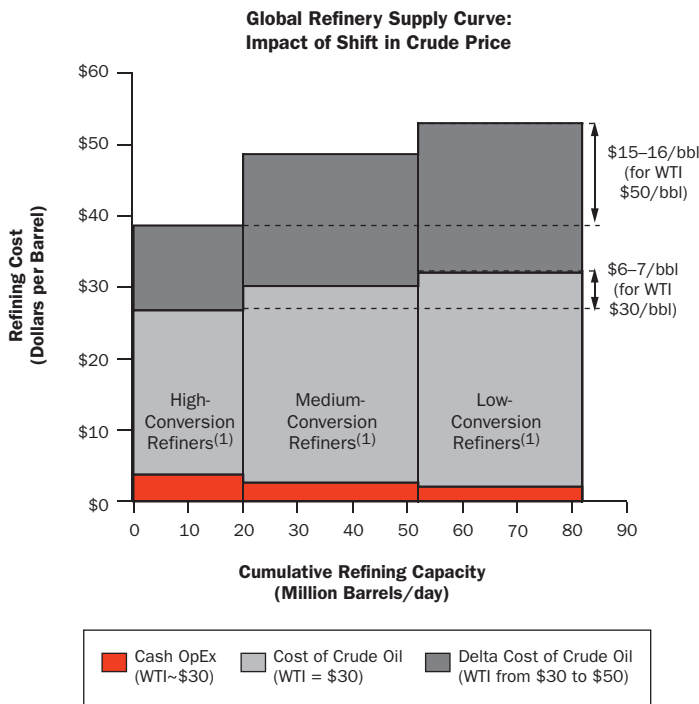
Exhibit 4

Light/Heavy Differential v. Hydroskimming Indifference Point⁽¹⁾



(1) Based on USGC yields, product and WTI/Maya crude price benchmarks
 (1) Based on Singapore yields, product and Tapis/Arab Heavy crude price benchmarks
 Source: PLATTS; Booz Allen Hamilton

Exhibit 5
Crude Price and Refining Margins



(1) High-conversion refiners defined as those with conversion-to-distillation ratio of 0.50 or more
 (2) Medium-conversion refiners defined as those with conversion-to-distillation ratio of 0.25–0.50
 (3) Low-conversion refiners defined as those with conversion-to-distillation ratio of less than 0.25
 Source: Oil & Gas Journal; PLATTS; Booz Allen Hamilton

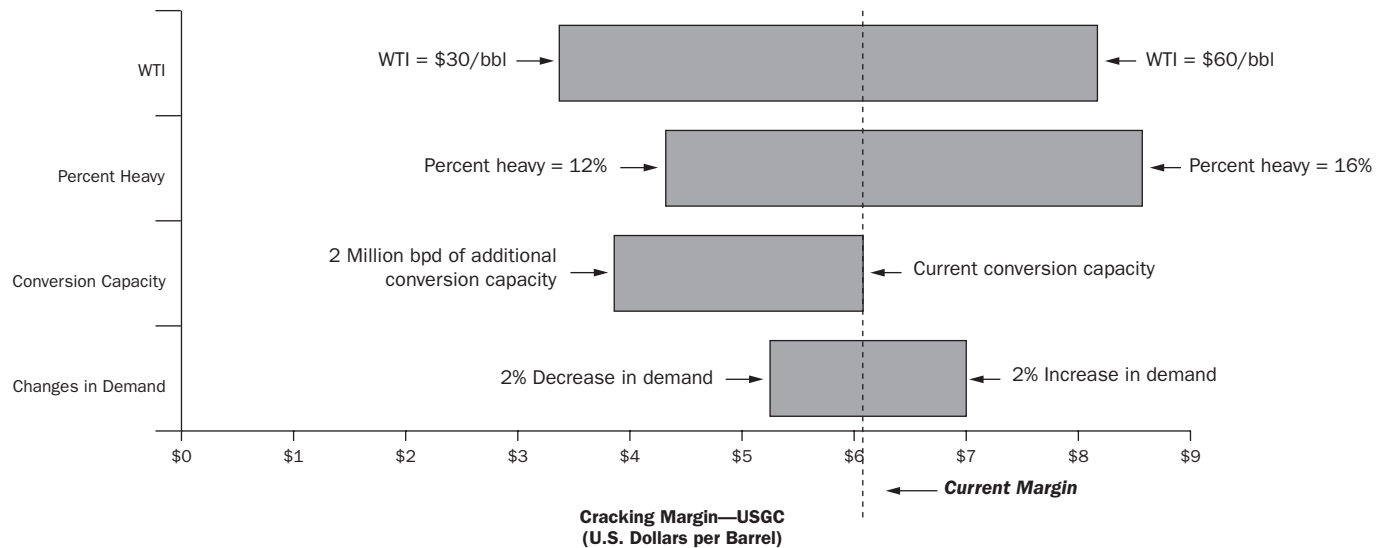
differentials “stretch” the supply curve by widening the gap between the least efficient refiners running expensive light crude and the most efficient running heavy, increasing the margins available to all capacity that is not incremental hydroskimming. Exhibit 5 illustrates this supply curve effect. (We can augment the complexity of our model by including indifference observations for sulfur and boutique fuels, which undoubtedly play a role—however, to make the insights clear, we have kept the overall model simple).

Perhaps the most intriguing result of this model is the role that absolute (light) crude price plays in setting refinery margins, also demonstrated in Exhibit 5. By requiring hydroskimming margins to be zero and capping the fuel oil price (relative to the price of alternative fuels), light product prices are driven by crude prices. The light/heavy crude differential will then vary with the absolute

crude price to make refiners indifferent given the existing product price set.

So in summary, there are four main drivers of industry refining margins: (1) the overall level of demand for light products, (2) the percent of heavy crude in the production mix, (3) the conversion capacity available, and (4) the overall price level for crude. Under market conditions like we have today (increasing demand for light products, constraints on conversion capacity, and no incremental light crude availability), refiners are forced to produce an increasing amount of residual fuel oil as a byproduct of meeting light product demand. To be absorbed in the market, the fuel oil must be priced competitively, effectively setting a cap relative to substitutes such as natural gas and coal in power and other price elastic uses. To incite refiners to continue to produce light products, avoiding negative marginal economics in

Exhibit 6 Cracking Margin Sensitivities



Source: Booz Allen Hamilton

incremental hydroskimming capacity, light product prices must rise, which they can given lack of substitutes in transportation applications. The resulting higher spread of light/heavy product prices works its way back to higher differentials for light and heavy crudes, which equilibrate to make refiners indifferent and hydroskimming margins equal to zero. The higher light/heavy crude differentials stretch the refining supply curve, driving extraordinarily high margins for those refiners with conversion capacity, even if it is fully utilized.

Changing the unprecedented equilibrium point we have seen in the last couple of years will require shifts in one or more of the four drivers. Exhibit 6 illustrates the impact on cracking refining margins for reasonable ranges for each of these drivers. Now let's look at the outlook for each of these drivers more closely (except for crude oil price, which remains anyone's guess).

Outlook for Margin Drivers

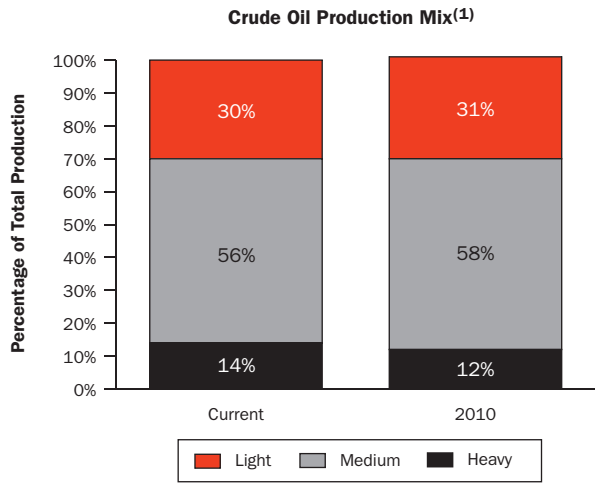
Percent of Heavy Crude in Production Mix. Soaring demand and exceptionally high crude prices offer a strong incentive for oil producers to increase capacity.

While producers don't get to choose the quality of crude they discover and develop, high light/heavy crude price differentials do provide incentives to favor lighter crude oil production over heavier where choices exist. Projecting quality of crude oil production requires a field-by-field analysis that is notoriously difficult, but our analysis of public information suggests it is reasonable to expect the crude oil mix to lighten slightly in the medium term (see Exhibit 7, page 7). This is in part due to the emerging attractiveness of unconventional resources such as Canadian heavy, which ironically gets placed in the market as light synthetic crude following upgrading. A lightening of the crude stream would act to compress the light/heavy differential, and the refining margin.

Conversion Capacity. For the bulls, the near-term outlook and timeline for investment in additional conversion capacity is perhaps the greatest evidence of a lengthy period of high margins. We calculate that at least 19 million barrels per day of new distillation capacity and 9.5 million barrels per day of new conversion capacity will need to be funded and built in the next decade. With the rate of capacity creep not increasing, this represents

Exhibit 7
New Crude Capacity Biased to Light

Recent Light Crude Capacity Announcements
<ul style="list-style-type: none"> ▪ 3 MMBPD incremental Saudi production will be Arab Light/Extra Light ▪ 1–2 MMBPD of light crude out of West and North Africa ▪ Caspian 1 MMBPD of light ▪ Condensates from additional gas production ▪ GTL will add 0.3–0.4 MMBPD of diesel ▪ 60%+ of 2–2.5 MMBPD Canadian tar will be light synthetic

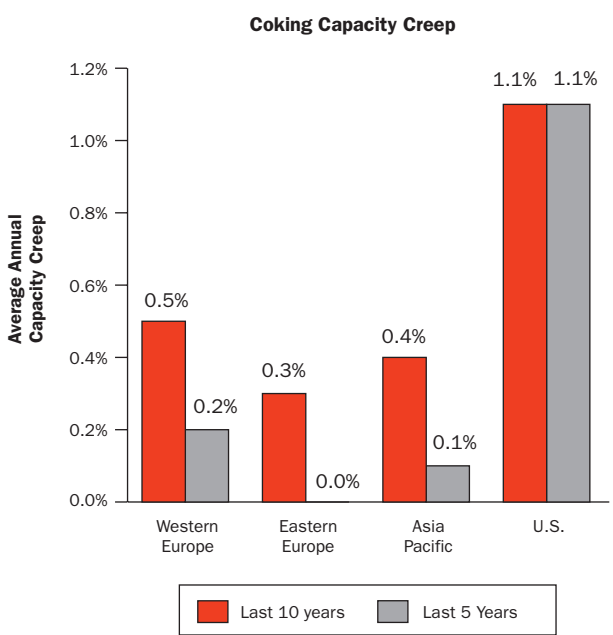
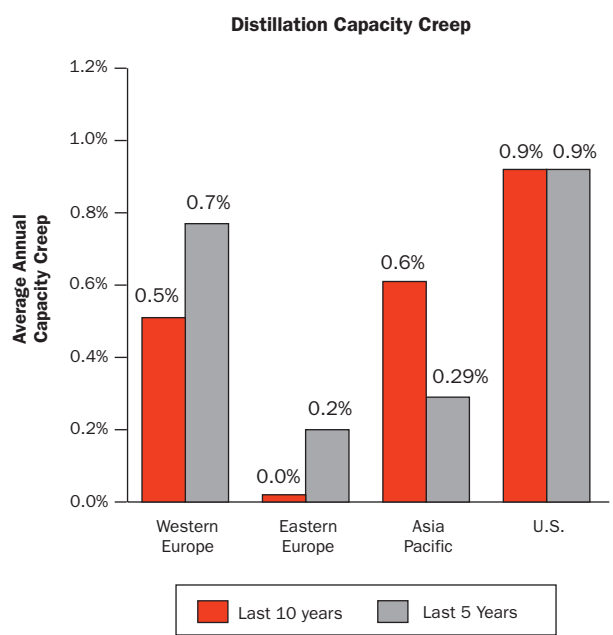


(1) Heavy >10, <26 API; Medium >26,<35 API, Light >35 API
Source: EIA; Company Presentations; ENI; Booz Allen Hamilton

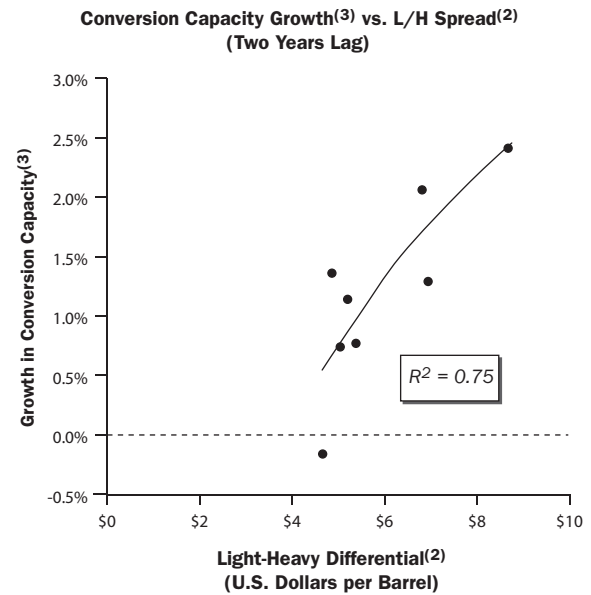
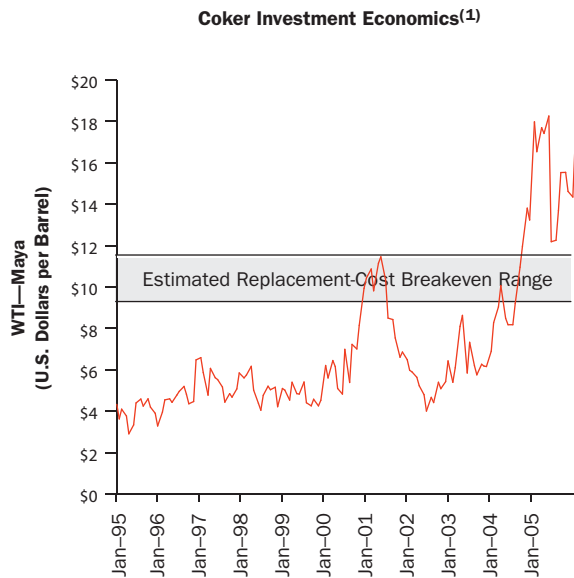
requirement for unprecedented new activity (see Exhibit 8). But the economics of conversion investment are attractive for the first time in almost a decade. Moreover, the high profits of recent years have left balance

sheets flush with cash—and with regulatory mandates largely satisfied, refiners report plans to devote a larger share of investment capital to commercial projects. Historically, refiners tend to invest at times of high oil

Exhibit 8
Distillation and Conversion Capacity Creep Trends



Source: Oil & Gas Journal Refinery Databases; EIA Refinery Databases; Booz Allen Hamilton

Exhibit 9**Conversion Economics and Investment Lag**

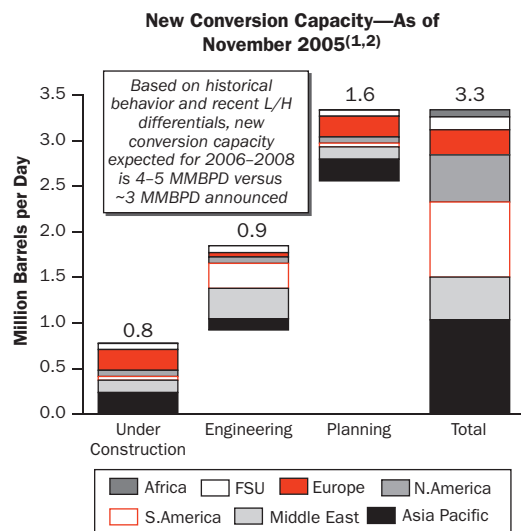
(1) CapEx in the \$10,000–14,000/bbl range; OpEx \$3.50/bbl; Annual maintenance ~2.5% of CapEx; 12% rate of return
 (2) WTI versus Maya
 (3) Relative to Growth in Distillation Capacity
 Source: Oil & Gas Journal; PLATTS; Booz Allen Hamilton

prices with investment lagging periods of high light/heavy differentials by about two years (see Exhibit 9).

Already, 3.3 million barrels per day in incremental conversion capacity has been announced or is under construction through 2010 (see Exhibit 10). While this amount falls short of what might have been expected based on historical behavior relative to light/heavy differential, there are signs that today's tempting economics are overcoming initial caution. Recently the pace of announcements has begun to speed up.

Changes in Demand. As we showed in Part I of this series the risk for a reduction of demand is real (see "Demand Scenarios: How Do They Look Now?" on page 12 of this viewpoint). In addition, the rise of alternative fuels could also impact the overall demand for petroleum products sourced from refineries. Hydrogen clearly will not be ready for prime time even in the medium term, but there have been a number of exciting developments in biofuels in Europe and the U.S. While the current shift from MTBE to ethanol will put more stress on the gasoline pool, the

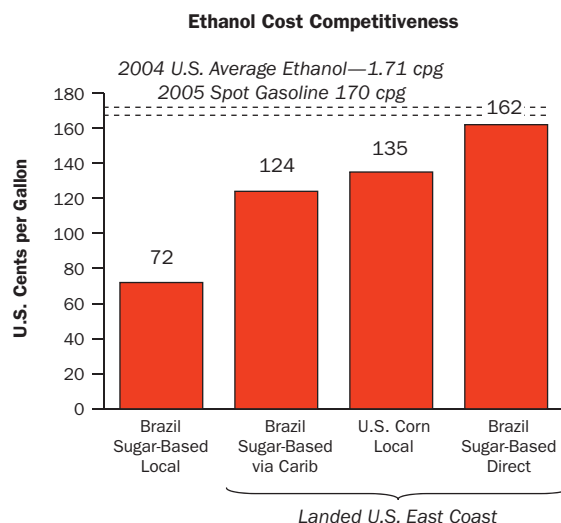
success of ethanol in places like Brazil, where 40 percent of cars have been outfitted to run entirely on the biofuel,

Exhibit 10**New Conversion Capacity—As of November 2005^(1,2)**

(1) Only announced plans are included
 (2) Excludes upgraders of unconventional oil
 Source: Oil & Gas Journal; Recent announcements; Booz Allen Hamilton

Exhibit 11
Ethanol as Transportation Fuel

Ethanol as Transportation Fuel	
<ul style="list-style-type: none"> Ethanol accounts for approximately 40% of fuel sold in Brazil <ul style="list-style-type: none"> Automobiles have been running on ethanol since the 1970s All cars run on at least 22% ethanol Approximately 40% of cars run on 100% ethanol Currently all cars in North America can run on some degree of ethanol blend <ul style="list-style-type: none"> All recent-model conventional gasoline engines can run on 10% ethanol blends (E10) with no engine modifications Approximately 3 million vehicles are Flex-Fueled Vehicles equipped to run on 85% ethanol blends (E85) 	



Source: Booz Allen Hamilton

raises the possibility of much larger scale penetration elsewhere. And improvements in ethanol economics are now making it more attractive versus gasoline (see Exhibit 11).

A Golden Age?: Margin Scenarios

Can today’s margins be sustained? We turn to three scenarios with various combinations of the key variables

that determine the light/heavy differential and therefore refining margins. For each scenario we estimate the impact on refining margins over a 10-year horizon (see Exhibit 12).

Across all the scenarios we see two things: a growth story and a cautionary tale. First, it is evident that we are in a new era, as major new investments will be required before refining margins return to historic averages. This

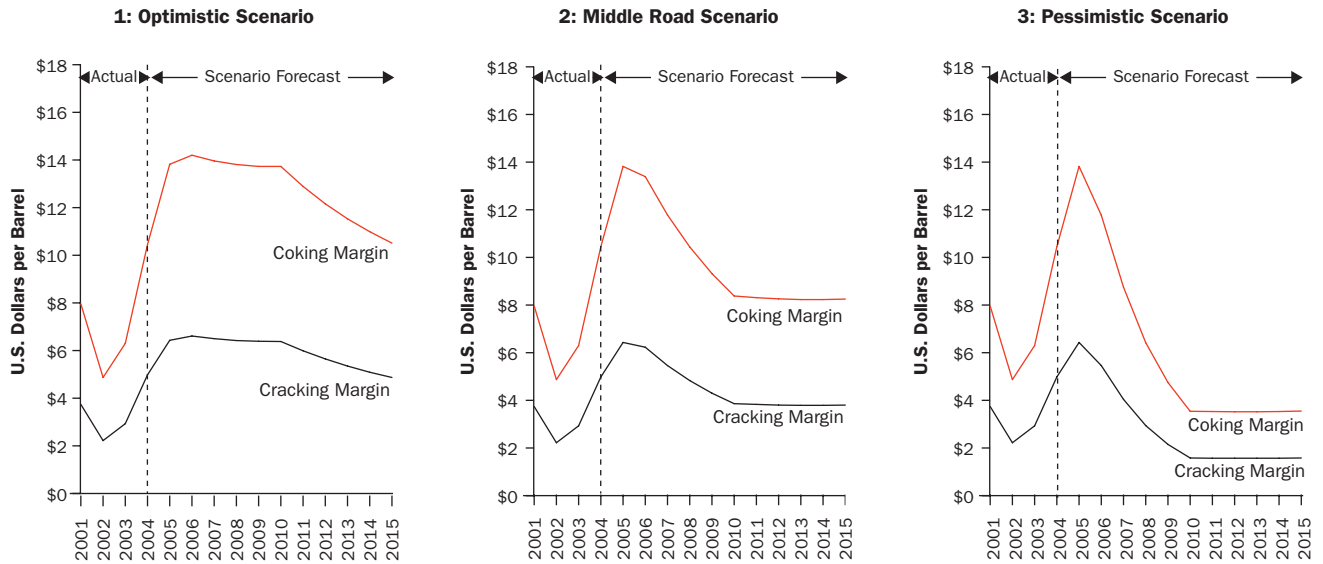
Exhibit 12
 Overview of Scenarios Considered

	Optimistic	Middle Road	Pessimistic
WTI Price	Constant \$50/bbl	Down to \$40/bbl	Down to \$30/bbl
Percent Heavy Crude	Up to 16%	Constant at 14%	Down to 12%
New Conversion Capacity	4.5 MMBPD till 2010	5.5 MMBPD till 2010	6.5 MMBPD till 2010
Demand	As in EIA Base Case	As in EIA Base Case	5% below EIA Base Case

Source: Booz Allen Hamilton

Exhibit 13

Impact of Scenarios on Refining Margins



Source: Booz Allen Hamilton

era could last three to five years, depending on oil prices and investment behavior. In addition there could be surprises around demand levels and supply alternatives (see Exhibit 13).

We also notice that coking margins reveal the highest risk/reward profile as they demonstrate greater variation across all scenarios than those for cracking. In other words, for any given scenario coking margins are more sensitive to changes in the economic drivers than cracking margins, suggesting lower-cost cracking capacity may be a more prudent investment approach.

Implications: What Are the Choices and Near-Term Actions?

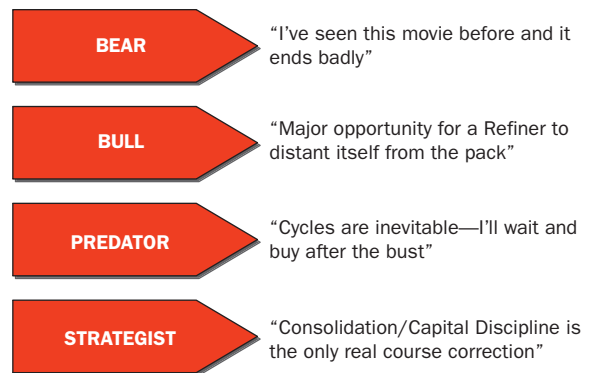
Given long lead times for new conversion and light crude production capacity, refining margins should remain strong for the next three to five years provided the crude price stays high. However, overinvestment in conversion is a real danger. So it's essential for market participants to avoid irrational exuberance and to adopt a measured approach that considers their current strategic position, perspective on future price moves, assessment of likely

competitive moves, and appetite for risk. In particular, both local and global refiners should approach their refinery investment decisions following a well-defined refining strategy. We see four potential approaches, which vary depending on one's outlook and risk profile (see Exhibit 14).

From our discussion with clients over the last year, as well as the spate of recent announcements, it appears to us that the industry's center of gravity has moved squarely

Exhibit 14

Strategic Alternatives for the Golden Age



Source: Booz Allen Hamilton

from bear to bull. While it may be arguable whether all the announced projects will get built, there is no doubt that this is a classic sign of the start of top-of-cycle thinking. In a capital intensive industry as fragmented as refining, perhaps there is no escaping an inevitable downturn without greater consolidation on a global scale. But with today's acquisition prices approaching replacement value, "strategists" have been few and far between.

In order to increase the chances of making the right choices, players will need to fine-tune their market intelligence—particularly to maximize their confidence in their assumptions on future crude prices, light crude production capacity, conversion investment trends, and overall demand trends—looking beyond their markets of operation to consider the outlook on a global scale, with particular focus on Asia. Given the dynamic nature of information, the uncertainty around projects moving from announcement to reality and the difficulty of interpreting competitor intentions, a robust strategy must be outfitted with signposts to guide the executive through a much more dynamic decision-making and implementation process.

Regardless, it makes sense in the short term to implement certain proven top-of-cycle tactics:

- *Reap the rewards.* Capturing today's high margins requires refinery availability, an increasing challenge for many companies in times of very high utilization. There is no better time to address the reliability performance of each refinery—current margins reward even small improvements.
- *Seek to lock in today's higher spreads.* Evaluate possible hedges against crude price declines. They are expensive, but so are rapid changes in margin environment, particularly for smaller, less diversified players.
- *Remain diligent on costs.* It is common for companies, especially for those who have lived through many years of poor returns and incessant cost cutting, to get "fat and happy" during the good times. At the end of the day, refining remains a commodity business, characterized in the not-too-distant past by productivity-driven long-term declining margin trends.
- *Grow as inexpensively as possible.* Creep remains a viable option for capacity growth, and some players have been much more effective than others at achieving it, primarily through superior application of new technologies. And with the industry's limited experience at building new capacity, world-class capital projects management becomes a differentiating capability.

Part I of this series showed how demand disruptions could dramatically worsen the economics of refining. Part II makes clear that the industry's own strategic and operational choices can have an equal or even stronger impact on results. By exercising rational restraint, players can achieve profitable growth—at least for the next several years. By bringing an overly bullish perspective to their business decisions, however, they will destroy margins the old-fashioned way: with a self-inflicted wound. Not many capital intensive industries have escaped this outcome. Those that have had some success at discipline are much more consolidated than refining.

Demand Scenarios: How Do They Look Now?

Last year, in Part I of this study, we looked at three scenarios to see how they would affect United States gasoline demand. While the scenarios differed in the timing and magnitude of the demand decreases they predicted, they all showed the U.S. moving rapidly from a place where demand outstripped supply to one where supply outstripped demand. Exhibit A summarizes the three scenarios impact on demand.

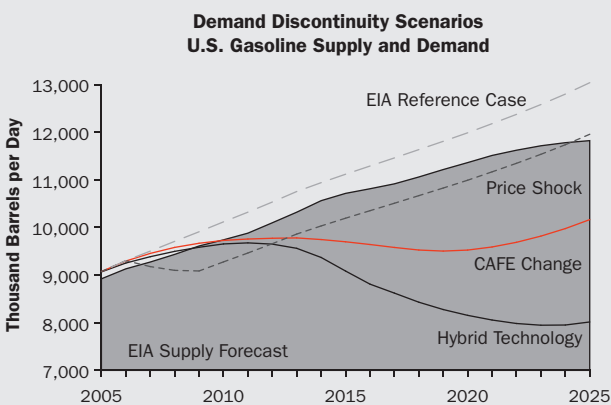
It seems only fair, with a year now passed, to see what new evidence has emerged to support or refute our demand scenarios:

- Price Shock.** This scenario showed substantial decreases in demand when gasoline prices spiked to an average real price of \$2.00/gallon and stayed there until 2007. High prices should encourage people to drive less and to trade down to smaller cars. Since last summer high prices have been the rule. The result has been flat gasoline demand growth year on year through November 2005, the first time since the recession in 1991 that demand has not grown. In addition, according to Ford, industry sales of the largest SUVs are off 18 percent in 2005. However, it may be that we will need prices in the range of \$3.50-\$4.00/gallon, the level in real terms at which gasoline's share of personal disposable income approaches that of 1980, before we see significant demand reduction (see Exhibit B).
- Regulatory Shift.** This scenario assumed that new standards were established requiring automakers to increase fuel efficiency for light trucks to 27.5 miles per gallon (mpg) by model year 2015. In August 2005, the Bush administration proposed the first changes to the CAFE standards in 20 years. The proposed plan calls for automakers to achieve overall light truck standards of 24 mpg by 2011, spread across six categories of vehicle size. We have not modeled the impact of the proposal, but there remains great disagreement between supporters and naysayers of ultimate impact on fuel demand.
- Technology Change.** The third and final scenario modeled for demand was that a new technology emerges that enables automakers to deliver vehicles with the efficiency of hybrids at little incremental cost, thus leading to rapid adoption. While hybrids remain more expensive than traditional vehicles, they are experiencing strong marketplace momentum. U.S. hybrid sales in 2005 are on track to be more than double what they were in 2004, with as many as 400,000 hybrid vehicles on the road by the end of 2005.

Clearly, the future will not see any one of these scenarios come to pass in its entirety. Instead, we believe, we are likely to see elements of each emerge and influence demand.

Exhibit A

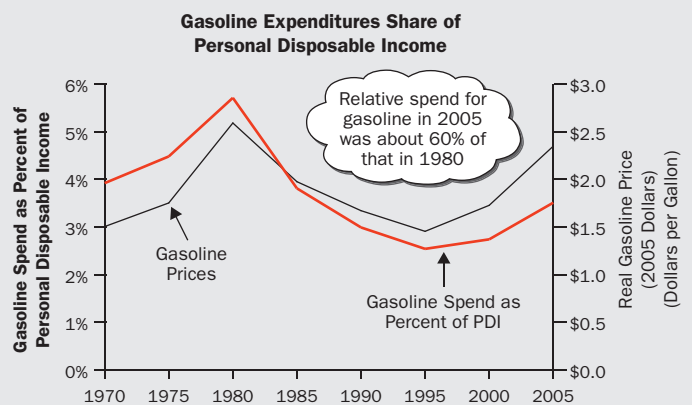
Demand Scenario Summary



Source: Booz Allen Hamilton

Exhibit B

Relative Gasoline Expenditure



Note: 2005 PDI assumed to grow by 2% from 2004

Source: Bureau of Transportation Statistics; Bureau of Economic Analysis; Energy Information Administration; Booz Allen Hamilton

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