Perspective

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U.S. Refining Trends
The Golden Age or the Eye of the Storm?

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U.S. REFINING TRENDS

The Golden Age or the Eye of the Storm?

With U.S. gasoline production projected to fall short of domestic demand for the foreseeable future, refiners are bullish. They see a world in which high-priced imports will set the domestic market price, making today's extraordinary margins commonplace. Could a historically cyclical industry be entering a golden age? Or are we just approaching the top of another cycle? Since the future is truly uncertain, we have developed three demand scenarios in Part I of this series (Part II focuses on supply) that challenge the conventional wisdom: price shock, regulatory shift, and technological discontinuity. In each case they suggest the potential for significant declines in medium-term demand, in one case transforming the U.S. into a net exporter by 2007. While we share the industry's short-term optimism, we also feel that assessing the impact of potential risks for the medium- to long-term offers valuable context for current strategic and operational choices.

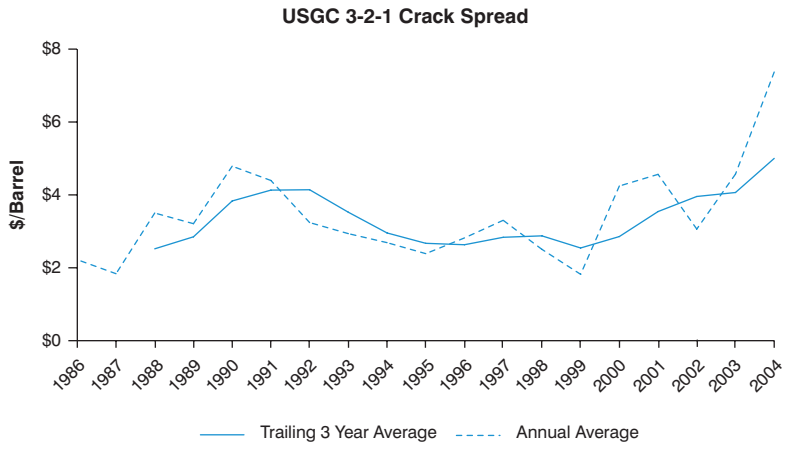
On the surface, things have rarely looked better for the U.S. refining industry. The last five years have seen impressive growth in margins (see Exhibit 1, page 2). And three factors suggest that the party is just getting started:

• *Steady demand growth.* Key industry sources project a surplus of demand over domestic supply—with a related growth in imports—as far as the eye can see (see Exhibit 2, page 2).

• *Constrained supply.* The U.S. regulatory environment effectively precludes the building of any new domestic capacity, while U.S. clean fuel regulations limit the ability of some of the world's excess capacity to meet U.S. demand. While Canadian, Caribbean and Western European refiners will continue to be able to meet clean gasoline specifications, as much as half of current imports from less traditional sources such as Eastern Europe and Latin America will not be available without substantial refining investments in those regions.

• *Steep supply curve.* The universe of domestic and international refining assets that can supply the U.S. is exceedingly diverse. Comprising large, low-cost domestic refineries of high-complexity, a hangover

Exhibit 1
Refining Industry Margins Improving



Source: EIA, Booz & Company

of smaller, higher-cost refineries kept in business through government exemptions, and high priced imports, this universe defines a steep supply (i.e. cost) curve. The slope of this curve implies that even small variations in demand can drive large changes in margin—we estimate each million barrels per day reduction or increase in demand can move long-term refining margins by 50 cents to $1 per barrel (see Exhibit 3). When read in the context of growing demand and relatively static supply, this curve tells forecasters and industry executives alike a story of sustained above-average profitability for U.S. refiners.

But this optimism is warranted only if the regular demand growth of the last two decades continues and/or no major increases in refining capacity emerge. In an environment of steady or declining real gasoline prices, such as that from the mid-1980s until recently, demand has been relatively easy to predict. But demand growth has not always been so linear (see Exhibit 4). For example, the period from 1970 through the early 1980s showed much more variable demand as the market responded to a variety of factors including regulation (the imposition of CAFE standards in 1975), the domestic economy (various recessions) as well as geopolitics (the 1973-1974 Arab oil embargo and the 1980 Iran/Iraq War).

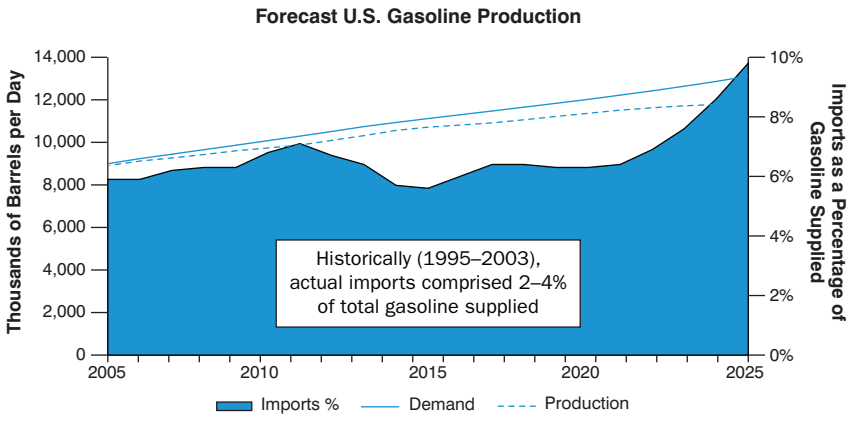
Can we count on steady demand growth to lead us to a golden age, or will we hit a bump in the road that returns this traditionally cyclical industry to its heritage of below cost-of-capital returns (see Exhibit 5, page 4)? In the remainder of this Viewpoint, we will focus on the drivers of gasoline demand and review a set of scenarios highlighting developments that could affect the outlook for U.S. refining.

A primer on demand

Gasoline demand has two drivers: (1) total miles driven and (2) the average efficiency of the fleet of cars on the road. Multiply one by the other and you have total demand.

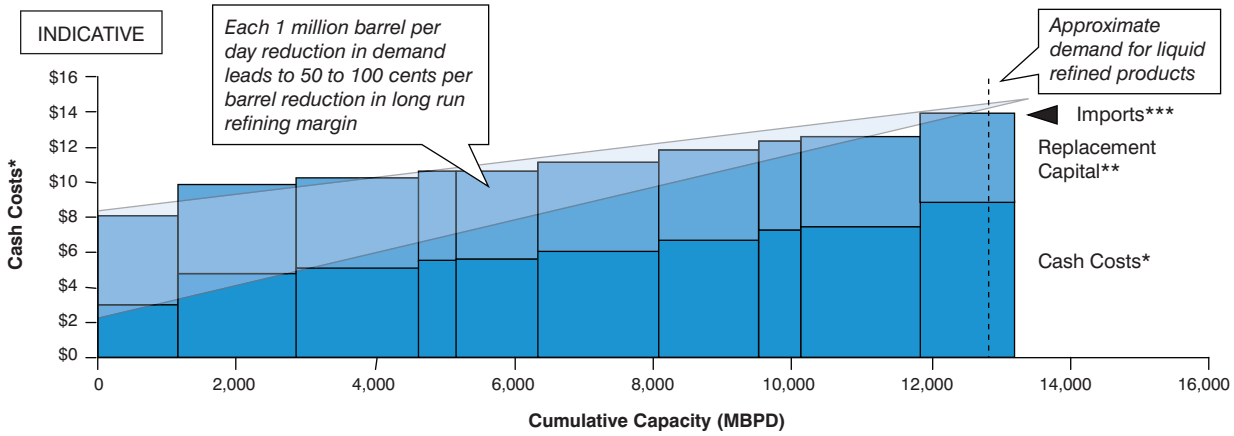
Total miles driven represents the accumulation of millions of consumer decisions including:

Exhibit 2
U.S. Supply Shortfall Drives Growth in Imports: 2005–2025



Source: EIA, Booz & Company

Exhibit 3
U.S. East of Rockies Refining Supply Curve



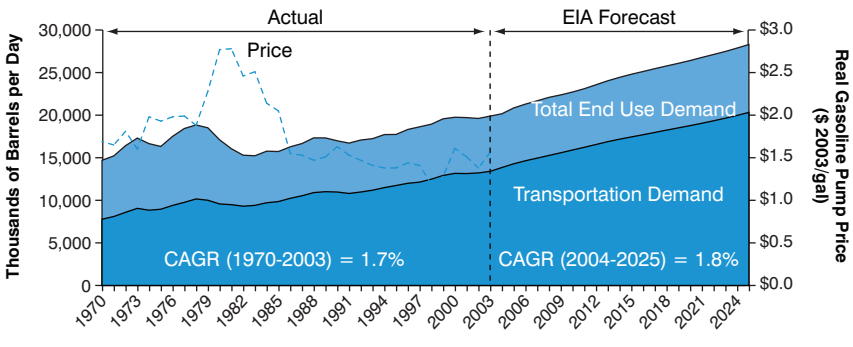
* Includes cash operating costs and incremental feedstock costs (relative to most efficient refiner)
** Required to generate 10% after tax return on $11,000 invested capital per bpd of replacement capacity
*** European imports shown as highest cost block assumed to be from average cost European refiner with 5cpg transportation costs
Source: EIA, Booz & Company

whether to drive, walk, or take public transport; whether to go alone or carpool; whether to take the scenic route or the highway; and whether to take the trip or stay at home. Miles driven varies inversely with gasoline price—as price goes up miles driven goes down. It is the easiest variable for consumers to adjust in the face of higher prices. After all, it's less expensive for a consumer to change behavior than to purchase a new, more fuel-efficient vehicle. Over the past 30 years, for every 10% annual increase (decrease) in gasoline prices, we have seen about a 1% decrease (increase) in miles driven.

Average fleet efficiency is determined by the rate of turnover in the installed base of vehicles—currently about 15 years—and by the size, power, and efficiency of new vehicles sold into the fleet. The last forty years have shown two distinct phases in the evolution of fleet efficiency (see Exhibit 6, page 4).

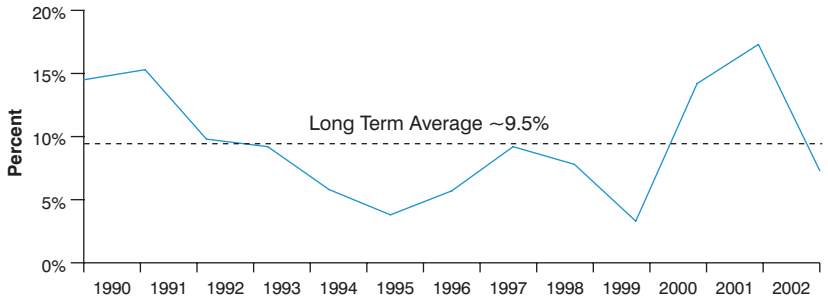
• *Consumers Trade Size for Greater Efficiency (1968-1985).* In a climate of concern over worsening air quality, gasoline shortages, and ultimately high and rising fuel prices, consumers opted for more efficient, less polluting vehicles. This shift in consumer priorities helped drive the U.S. growth of the Japanese auto makers, whose product lines of high quality, smaller cars offered more of what consumers sought. Public policy, in the form of the CAFE standards, sustained this trend toward

Exhibit 4
U.S. Petroleum Consumption



Source: EIA, Booz & Company

Exhibit 5
*U.S. Refining Returns on Capital**



* USGC refinery of average complexity
Source: EIA, Booz & Company

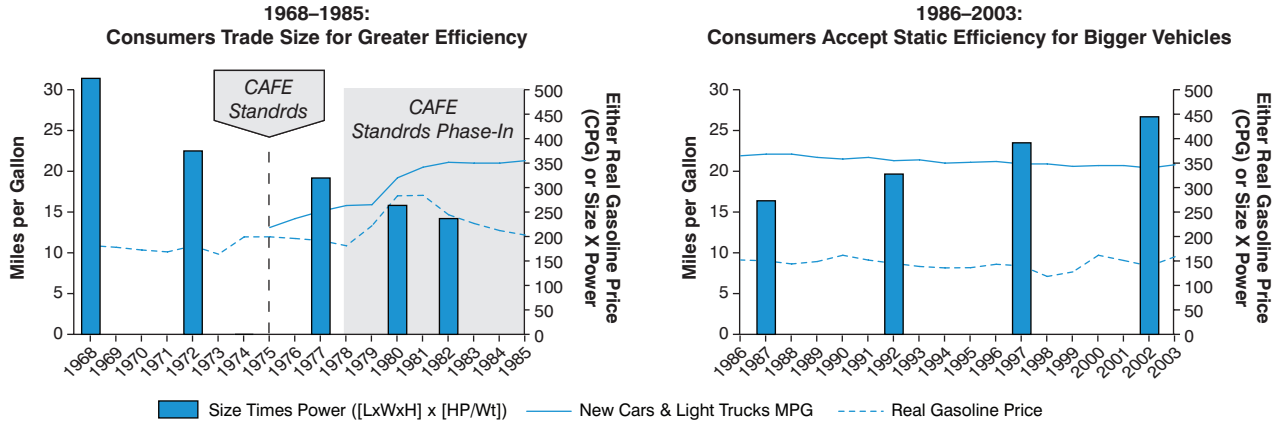
smaller, more efficient vehicles by mandating that from 1978 through 1985, fuel efficiency for cars increase from 18.0 to 27.5 miles per gallon (MPG), and for light trucks from 17.2 to 20.7 MPG.

• *Consumers Accept Static Efficiency for Bigger Vehicles (1986-present).* In an environment of steady and lower gasoline prices, consumers were happy to trade off greater efficiency for more comfort and greater safety. Automakers were equally happy to respond with more profitable minivans and SUVs along with many safety innovations such as anti-lock brakes. As a result, from 1986 to the present, the size of the average new car grew by 21% and its power by 56%. Yet the fuel efficiency of the average new passenger vehicle stayed relatively constant over this period, an impressive engineering feat. Indeed, had the average size and power of the fleet remained constant after 1980, we estimate the U.S. refining industry would have been a net exporter of 50 thousand barrels per day (MBD) of finished gasoline in 2001—rather than a net importer of about 320 MBD.

Historically, both miles driven and fleet efficiency have changed in response to consumer priorities and the external environment. In particular, we have seen gasoline prices, government regulation, technological innovation (e.g., the pioneering of new engine technologies), and consumer consciousness (e.g., the environmental movement of the 1960s and 1970s) influence demand.

Going forward, these factors will surely continue to shape demand for gasoline. But how sensitive is demand to unexpected shifts in these variables? What, for example,

Exhibit 6
Two Phases of Fleet Efficiency



Source: EPA Light Duty Automotive Technology & Fuel Economy Trends, EIA, Booz & Company

might be the impact of the changing priorities of an aging population on the fleet and on miles driven? Of increasing rather than level gasoline prices? Of new regulatory mandates? Of a major innovation in engine technology? To explore some of these questions, we have modeled three demand scenarios: price shock, regulatory shift, and technological discontinuity (see Exhibit 7). These three factors are clearly inter-related, but for analytical purposes we look at them separately.

Demand scenario: Price Shock

This scenario models the impact on demand if recent upward moves in price are sustained. We look at two different variations from the EIA's projected reference price for gasoline:

- Price increases 2% per annum over the rate assumed in the EIA reference price; and,
- Price spikes to 140% of EIA reference price in 2007 and then increases at the EIA growth rate through 2025

Could these come to pass? The current geopolitical uncertainty in Iraq and Saudi Arabia has already pushed prices higher than these levels in recent months. If the situation is not alleviated, or if petroleum supplies are affected, or if high rates of demand from China and India put further pressure on supply, or if current refinery tightness persists, or if the capacity of the logistics infrastructure continues to be stressed, or if U.S. fuel taxes are increased to address environmental concerns, cover federal deficits, or fund an energy independence initiative, higher prices could well result.

How would this influence demand? In addition to leading to a short-term decrease in miles driven, it would, if sustained, likely have an impact on the composition of the fleet. In the last period of persistently high prices—1968 through 1982—we saw a dramatic shift in consumer priorities toward smaller, more efficient cars (see Exhibit 8, page 6).

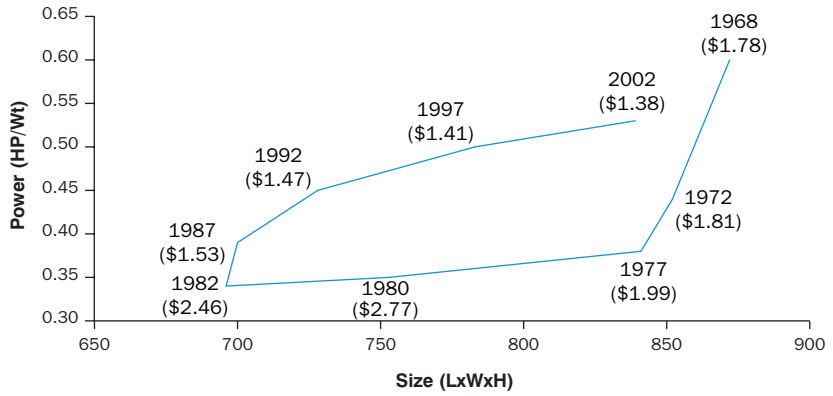
There are already signs that consumer behavior is shifting in response to higher prices. Sales of SUVs are slowing, leading manufacturers to offer increased incentives. A recent poll by Kelly Blue Book and Harris Interactive reported that 40% of car shoppers said that gas prices had some effect on their purchase decision, and that 17% had actually changed their purchase plans because of higher fuel costs.

Exhibit 7
Summary of Demand Scenarios

Type of Discontinuity	Scenario	Hypothesized Impact
Price Shock	• Geopolitical and/or U.S. refining structural factors lead to sustained increase in prices of as much as 40% at the pump	• Drivers drive fewer miles in the short term • Drivers "trade down" to smaller, more fuel efficient cars medium term
Regulatory Shift	• Environmental and/or energy policy results in increase in CAFE standards bringing light trucks to parity with cars by 2015	• OEMs choose to meet requirements by promoting diesel vehicles • Gasoline demand decline not quite offset by diesel demand increase
Technology Change	• Cost and performance improvements due to technology and scale increase penetration of hybrids to up to 80% of new vehicles by 2016	• Hybrid vehicles "cross the chasm" from a niche to mainstream product, materially altering the MPG of the fleet • Hybrid engines become standard part on all new autos • Drivers "trade down" to smaller, more fuel efficient cars medium term
Change in Consumer Consciousness (Not Modeled)	• "Event" causes consumers to reevaluate need for big, powerful, high emission cars	• Consumer demand accelerates auto introduction of more fuel efficient vehicles • Government responds to same event with new regulations

Source: Booz & Company

Exhibit 8
Average Passenger Vehicle Size and Power by Model Year (volume weighted)*



* New passenger cars and light trucks
Note: Real prices per gallon of gasoline for each year are shown in parentheses
Source: EPA, EIA, Booz & Company

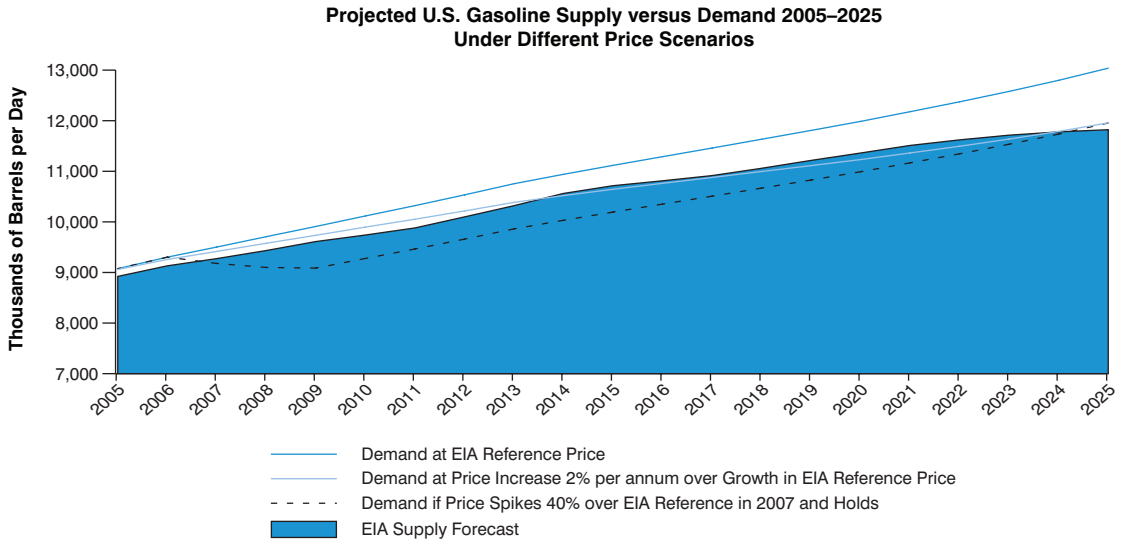
Our analysis suggests that the demand impact depends on how much and how quickly price changes (see Exhibit 9). Larger and more abrupt price shifts have a greater impact than smaller increases that phase in over time:

- Were gasoline prices to spike to an average real price of $2.00/gallon (140% of the EIA reference price) and stay there until 2007, we would see demand fall below domestic supply in 2007; by 2010, demand relative to the EIA reference case would be dampened by 8% or 840 MBD.
- With price increasing at 2% faster than the EIA forecast, we would see demand 2% or 220 MBD below the EIA reference case in 2010, and supply exceeding demand by 2014.

Demand Scenario: Regulatory Shift

What would happen to demand if the CAFE standard for light trucks were brought to parity with that for cars? We assume a new standard would be phased in starting with a revised model year 2006 (MY2006) target of 23.0 MPG and increase to 27.5 MPG for MY2015 in annual increments of 0.5 MPG. We further

Exhibit 9
Demand Scenario: Price Shock



Source: EIA, Booz & Company

assume that manufacturers will be unable to meet these mandates fully through improvements in gasoline technology, but instead will have to turn to diesel engines.

Imagine growing frustration over gasoline prices and U.S. dependence on foreign oil creating a political climate conducive to regulation and conservation. Auto makers discover that consumers accustomed to SUVs are resistant to trading down to much smaller cars. In trying to satisfy both consumers and the regulatory mandate, engineers reach the practical limits of gasoline technology. Diesel emerges as the most cost-effective current alternative and OEMs, perhaps in concert with oil companies, manage to overcome consumers' negative perceptions of earlier generations of diesel vehicles.

Could this scenario happen? A number of indicators support it:

• *Periods of high prices and supply risk encourage government action.* In 1975, following the Arab oil embargo, and with real gasoline prices averaging around $2.00/gallon, Congress passed the Energy Policy and Conservation Act that established CAFE standards starting with MY1978 at 18 MPG for cars and 17.2 MPG for light trucks. The law called for annual increases in efficiency to 27.5 MPG for cars and 20.7 MPG for light trucks by MY 1985. The effect of these regulations has been for OEMs both to deliver substantial increases in the efficiency of their fleets and to manage their product mix to meet standards at the highest margin (i.e., emphasizing high-margin light duty trucks).

• *Supply-side mechanisms such as CAFE have been favored by regulators.* Other approaches to change incentives for consumers, such as taxes on gas guzzlers or tax credits on fuel-efficient cars have not been widely embraced. Moreover, the National Highway Traffic Safety Administration has already announced light truck CAFE increases to 22.2 MPG by MY2007. And John Kerry has indicated during campaigning that he favors a new CAFE standard for cars at 36mpg, a 33% increase over current levels.

• *OEMs are beginning to express optimism about diesel.* While OEMs are likely to be able to meet some portion of these increased standards relatively inexpensively with existing gasoline technologies such as multi-valve overhead cams and cylinder deactivation, diesel is starting to be discussed. Mercedes and Volkswagen recently announced that, with the availability of cleaner U.S. diesel, they will be able to develop new, cleaner-burning diesel engines in time to meet California's stringent clean air regulations for trucks scheduled to take effect in 2007. Their optimism suggests that diesel vehicles will be available to consumers throughout the U.S.

• *Europe's OEMs and consumers have embraced diesel.* In Europe, where fuel is much more expensive than in the U.S., diesel engines have achieved much greater penetration. Diesel's share of new light vehicle sales was over 40% in 2003, up from just 14% in 1990. European consumers have adopted diesel technology primarily because it is 25-40% more efficient than its gasoline counterpart, and because diesel fuel is lower priced than gasoline, aided by tax incentives. European regulators have promoted diesel fuel because of its fuel efficiency and its low-sulfur content. The E.P.A. has published rules requiring that U.S. diesel fuel be equally clean by 2007.

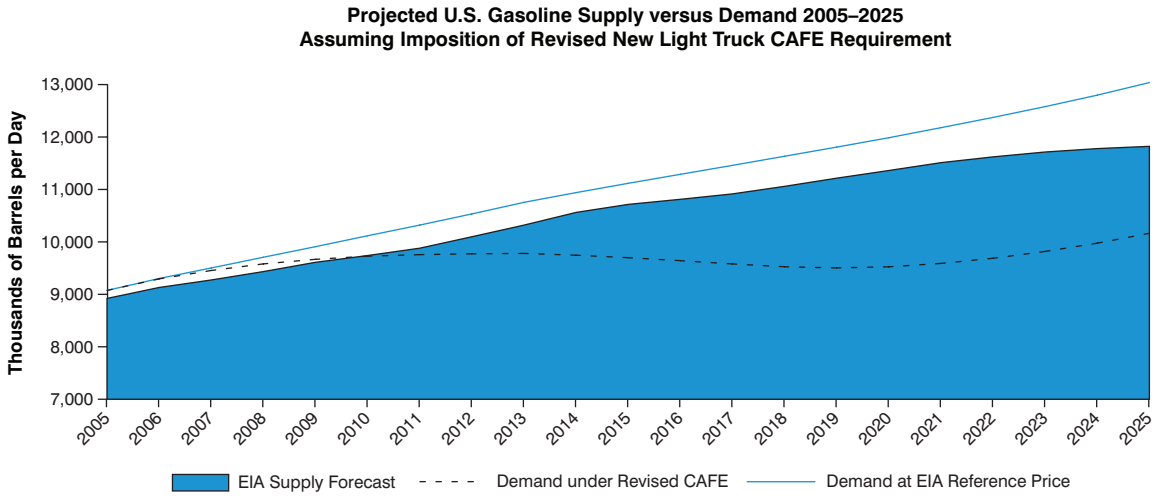
Our analysis suggests that the impact of such new standards on gasoline demand could be substantial in the long-term, but slower to take root because the effect is tied to fleet replacement (see Exhibit 10, page 8). We think these more aggressive standards would drive a substantial increase in diesel vehicle penetration in the U.S.—from 2% of new light truck sales in 2006 up to 46% in 2015—that would lead to a significant decline in gasoline demand:

• Gasoline demand would decrease by 4% or 390 MBD by 2010 and by 13% or 1,400 MBD by 2015; and,

• By 2012 diesel vehicles would represent 43% of light trucks sold and gasoline supply would exceed demand.

For refiners, the increase in diesel demand would soften the blow of the decline in gasoline demand, but not on a one-to-one basis since diesel engines are more efficient. In this scenario we estimate that U.S. refinery utilization could fall by at least 5% points in the next decade. In addition, refiners' returns may be pressured even further if significant capital expenditures are required to make the switch toward increased diesel production.

Exhibit 10
Demand Scenario: Light Truck CAFE Standards Stiffened



Note: Scenario assumes that CAFE standards for light trucks increase 0.5 MPG/year from 23.0 MPG in 2006 to 27.5 MPG in 2015
Source: EIA, CAFE Mix Management Simulation, Booz & Company

Demand Scenario: Technology Discontinuity

How would gasoline demand be affected if a technological breakthrough reduced or eliminated the manufacturing cost differential between hybrids and traditional gasoline engines? Were this to happen, hybrid adoption could follow the path of other successful automotive technologies such as fuel injection and anti-lock brakes. In this situation, over time, hybrid technology would become a standard feature of all cars rather than a niche product.

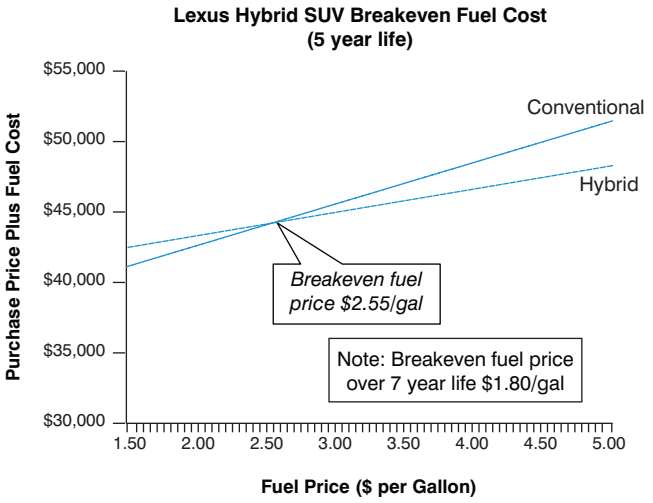
Is this scenario plausible? The history of the automobile is a story of extraordinary innovation in combustion techniques, materials, safety, and fuel efficiency. This scenario does not require that the innovation be in hybrid technology. Any breakthrough that delivers the efficiency of hybrids without extra production costs would do. We believe, however, that hybrids are the most promising among competing technologies such as hydrogen and fuel cells, because they offer the fewest technical and infrastructure challenges and have the first mover advantage. For this scenario to come to pass and have significant demand-side impacts, you would also have to assume that the more efficient engine would not encourage further increases in the size and power of the fleet—in effect reversing the trend of the last twenty years.

The consumer economics of hybrids are not yet fully known. OEMs sell the cars at a three to five thousand dollar premium over comparable all-gasoline models. So far, resale values and reliability are on a par with traditional vehicles. Battery life, however, is an important open question. With replacement batteries currently costing three thousand dollars, miles per battery in actual use will be a critical element determining long-term consumer enthusiasm for hybrids.

Even so, hybrids—at current pricing—have achieved strong sales momentum and positive critical attention. Currently demand is so strong that dealers are charging a premium over list price. Hybrid demand is, however, inspired by more than fuel cost. Moral and political values—such as the desire to protect the environment or to reduce U.S. dependence on foreign oil—have played and may continue to play an important role. And soon a much broader selection of vehicle types will be available with hybrid engines, enabling automakers to cater to consumer desires for size and power with more efficient, lower emission vehicles (see Exhibit 11).

Exhibit 11
Hybrids are Coming Closer to the Mainstream

Hybrid Launch Dates in North America	
Make and Model	Release Date
Honda Insight hatchback	December 1999
Toyota Prius sedan	June 2000
Honda Civic sedan	April 2002
Ford Escape SUV	December 2003
Chevrolet Silverado pickup	2004
GMC Sierra pickup	2004
Honda Accord sedan	2004
Honda Pilot SUV	2004
Toyota Camry sedan	2004
Lexus RX330 SUV	2005
Saturn VUE SUV	2005
Chevrolet Equinox SUV	2006
Nissan Altima sedan	2006
Chevrolet Malibu sedan	2007



Note: Assumes Hybrid RX 400 with net purchase price premium of $3,300 ($3,800 price premium offset by hybrid tax deduction valued at $500) over 3.3L 6cyl conventional RX 330. With 62% city/38% highway driving split, hybrid averages 36mpg; Conventional averages 20mpg. 12,000 driving miles per year.
Sources: Auto manufacturers; Edmund.com, Booz & Company

The Lexus Rx400h, for example, will be priced at a 10% premium (approximately $4,000) over its all-gasoline counterpart. This premium will be offset by gasoline savings of about $2,500 over five years—and in the U.S. by a tax incentive worth about $500. So long as reliability holds and replacement battery costs remain in check, the Lexus will be close to breakeven for consumers, particularly in high fuel price environments. With recent average gasoline prices topping $2.00/gallon, the gas price is beginning to approach the consumer's breakeven at today's hybrid vehicle prices.

How could cost-parity hybrids affect demand? We looked at three different adoption rate cases (see Exhibit 12, page 10). Each had a profound impact:

• *Low adoption.* This case is based on the rate of adoption of the minivan and assumes that hybrids achieve about a 4% share of new vehicles by 2010, and over 7% by 2015. By 2010 gasoline demand would be 1.5% or 150 MBD below the EIA forecast, and by 2015, it would be about 300 MBD short. However, the U.S. would remain a net importer in this scenario.

• *Medium adoption.* This case parallels the growth rate of the SUV. It assumes that hybrids achieve a 10% share of new vehicles by 2010, and 20% by 2015. By 2010 gasoline demand would be 3% or 300 MBD below the EIA forecast. Demand for 2015 would fall 7% or 800 MBD short. The U.S. would be a net exporter.

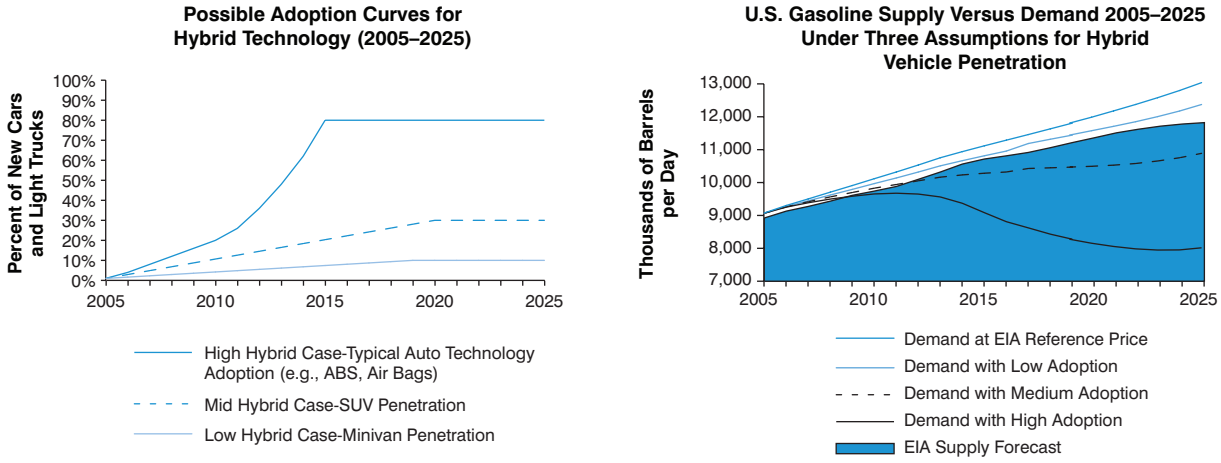
• *High adoption.* This case mirrors the penetration of highly successful automotive technologies such as air bags and anti-lock brakes that have rapidly moved from innovation to relatively standard parts of the vehicle. It assumes that hybrids achieve a 20% share of new vehicles by 2010, and 80% by 2015. By 2010 demand would be 5% or 460 MBD below the EIA forecast. Demand for 2015 would fall 18% or over 2,000 MBD short.

Scenario summary

So what do these scenarios tell us? They support industry bullishness in the short term: in all cases demand is projected to exceed supply through at least 2006.

Yet they each suggest a cautious approach to the medium term. Interestingly, the sustained price shock depresses demand more than the other scenarios through at least 2010, but technological

Exhibit 12
Demand Scenario: Accelerated Hybrid Adoption



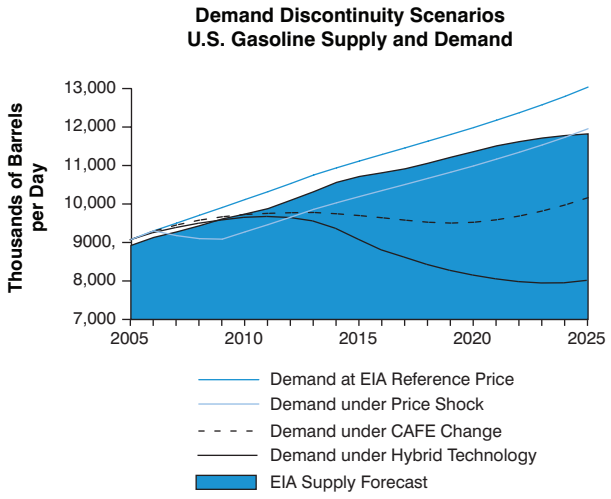
Source: EIA, Booz & Company

discontinuity and regulation have much more significant long term impacts (see Exhibit 13).

These lower demand levels would affect refining margins significantly. Since each million barrel per day decrease in demand reduces long term margin by fifty cents to $1 per barrel, these scenarios raise substantial concern about maintenance of high long-term margins.

If nothing else, it is clear that executives need to incorporate the possibility of a downturn into their planning.

Exhibit 13
Demand Scenario: Summary



Gasoline Demand Change Relative to EIA Reference Case (MBD/%)

Scenario	2010	2015
Price Shock	(840 MBD) (8%)	(920 MBD) (8%)
Regulatory Shift	(390 MBD) (4%)	(1,400 MBD) (13%)
Technology Change	(460 MBD) (5%)	(2,000 MBD) (18%)

Source: EIA, Booz & Company

U.S. Refining Trends Part II: Supply Drivers

In addition to demand drivers, supply-side issues will also play a major role in determining whether we have entered a new era in refining.

Indeed, capacity and flows, both absolute and the ability to meet required product specifications, have played a more critical part in the recent past in setting margins, as demand growth has been relatively steady.

How will refiners react to prosperity? What supply-side factors could prevent the 'Golden Age' from being sustained? In part II of "Refining Trends", we will explore some of the more interesting supply-side drivers and scenarios. For example:

- What role could latent, or mothballed, capacity have in meeting demand growth?
- What will be the ability of European and Asia Pacific/Japan refiners to supply U.S. gasoline needs?
- Who will supply the world's fastest growing economies in China and India and what is the implication for U.S. refining?
- What new sources of product could emerge, such as from Canadian Oil Sands and Gas-to-Liquids developments?

Implications for action

Refining industry leaders, faced with the potential for material changes in medium-term demand, need to focus on taking maximum advantage of today's margin opportunities while weighing longer-term actions carefully. A number of strategic and operational moves make sense:

• *Focus on reliability.* If the era of strong margins is to be short-lived, few things are more important than maximizing short-term plant availability. A review and enhancement of operational and maintenance practices can help you take best advantage of current market conditions.

• *Enhance the quality of your balance sheet.* Consider paying down debt or issuing equity to maximize your financial flexibility for uncertain market conditions and unexpected opportunities.

• *Assess your holdings.* Review your refining portfolio. Decide if you're committed for the long-term. If not, the current seller's market is an ideal time to divest. If so, look carefully at all efficiency and expansion investments.

• *Practice capital discipline.* Don't evaluate investment in long-lived assets on the assumption that tomorrow's margins will mirror today's. Instead, justify them based on short-term payback or lower margin expectations.

• *Watch your overall expense levels.* Don't assume the good margins are forever. Keep expenses from creeping up and maintain the leanest possible operation. It's good insurance in the event of a downturn.

• *Develop contingency demand sources.* Get to know overseas customers that could help maintain your utilization levels should domestic demand decline. China, Brazil, and Mexico are all markets where local demand growth is likely to outstrip the growth in local refining capacity.

It is unlikely that any one of these scenarios will come to pass in its entirety. Since they are not mutually exclusive, however, there is a good possibility that elements of each will characterize the future market and lead to changes in consumer behavior that will reduce demand. If demand does fall, the hoped for golden age will turn out to have been a mirage. Those executives and companies that were prepared for the potential of a demand shortfall will find themselves best positioned for the next cycle.

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