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Petroleum Refining: Economic Performance and Challenges for the Future

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Summary

The petroleum refining industry provides products that are critical to the functioning of the economy. Virtually all transportation, land, sea, and air, is fueled by products that are refined from crude oil. Industrial, residential, and commercial activities, as well as electricity generation, use petroleum-based products. Along with volatile changes in crude oil prices, the industry has faced evolving health, safety, and environmental requirements which have changed and multiplied product specifications and required capital investment in refineries.

Since the late 1990s, the industry has undergone significant structural change which might alter its profitability requirements, its ability to provide stable product volumes to the consuming market, and its ability to adapt to current and future environmental requirements.

Two significant structural changes characterize the industry. Mergers, acquisitions, and joint ventures have changed the ownership profile of the industry, altering concentration patterns both regionally and nationally. A change in the business model from an integrated component, to a stand-alone profit center, has focused attention on earning competitive profit rates at each stage in the production chain. Evidence suggests that the new market structure and business model might demand better economic performance from the industry. Regulatory compliance to meet congressionally mandated environmental standards, both on refined products and refinery sites, requires substantial capital investment by refiners, and has resulted in reduced profitability, according to the Energy Information Administration (EIA). To the extent that continued capacity expansion and technological investments are reduced, or not undertaken, because of low historical rates of return (even though recent returns are higher) U.S. dependence on imported refined products might increase, or product markets could be disrupted by shortages and price spikes.

As the 110th Congress considers energy legislation, it is likely to be concerned with domestic energy security and market stability, issues linked to the performance of the petroleum refining industry. Increased imports of refined products, particularly motor gasoline, combined with growing imports of crude oil, could make the United States increasingly vulnerable to shocks originating in the world oil market. Importing motor gasoline into the United States in appropriate volumes may become increasingly difficult because of the unavailability of world supplies consistent with U.S. fuel specification requirements.

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Petroleum Refining: Economic Performance and Challenges for the Future

The petroleum refining industry processes crude oil and produces a variety of products that are used in the transportation, residential, commercial, and industrial sectors of the economy. In 2007, over two thirds of refinery output went to transportation uses, nearly a quarter went to industrial uses, and the remainder was used in residences, commercial activities, and electricity generation. The transportation sector remains the most heavily dependent on petroleum, drawing over 95% of its fuel needs from refineries.

Because the refining industry plays such a key role in providing energy for the U.S. economy, its structure and economic condition are matters of national interest. In recent years, the industry has undergone significant change. The traditional industry model, based on ownership by vertically integrated oil companies with profitability viewed within the context of a linked supply chain, has been altered by companies and joint ventures whose primary business is refining. Increasingly, the business model for these firms, as well as the integrated oil companies, is the stand-alone profit center. Refiners now must earn market rates of return for investors, as well as returns sufficient to make investments in expansion, technological improvements, possible business restructuring, and to meet environmental regulations, both with respect to refined product specifications and refinery site operations and expansion.

Should the industry fail to meet these market-based performance standards, policy makers may be faced with the prospect of weighing the costs and benefits of decisions taken to mitigate supply and price volatility, especially in gasoline markets. If the industry determines that it is unable to invest sufficiently to meet projected demand increases, additional supplies of refined products will likely be imported. If imports were to increase significantly, policy makers might need to prioritize the needs of the local markets within the context of national energy security goals. The ability of the refining industry to meets its economic challenges will likely determine, in part, the nature of the energy challenges facing Congress. This report seeks to describe the recent performance of the refining industry, to evaluate the structural changes that are occurring in the industry, and to analyze the nature and effects of the challenges confronting the industry.

Refining Economics

When considering the economic performance of a petroleum refiner, several characteristics should be noted. First, the production process is capital intensive, and technological improvements are embodied through investments in the basic refinery. As a result, any circumstance which affects the availability, or allocation, of capital investment can have significant structural effects on the firm and the industry. Second, the major variable cost in the production process is crude oil, the price of which is determined in the world petroleum market. Third, while labor and other variable costs are relatively small fractions of total costs, a great deal of attention is given to minimizing them in the interests of enhancing profit margins. Finally, regulatory costs, both capital and operational, required to meet congressionally mandated environmental standards on both refined products and refinery sites, increase as new requirements are phased in.

Evaluating the economic performance of the petroleum refining industry is complicated by the fact that many refineries can use crude oil of lower quality as an input, while others cannot. Crude oil can be of lighter or heavier density, as well as having a higher or lower sulfur content. The density of the crude oil is important because, in general, a lighter crude oil input yields a lighter product mix. A lighter product mix is important because lighter products are generally in higher demand, and yield higher prices for the refiner.

Does this mean, then, that refineries that are able should always use the lightest crude oil available? Not necessarily, if the crude oil market pricing mechanism is working well. The market compensates for differences in the quality of crude oil by a price differential, the light-heavy price spread. However, at any given time, the actual, specific spread value for any set of crude oils is also influenced by relative availability on the world market as well as the location of the oil. As a result, the value of the spread changes, and, at any given time, the purchase of either light or heavy crude might be warranted by economic conditions, if technologically feasible for the refiner.

Table 1 shows the behavior of the light-heavy price spread, over time, measured in constant dollars. Following a historic peak in the late 1970s, the spread dropped sharply with the general collapse in the price of oil in the mid-1980s. In the early 1990s, the spread increased relative to the low values of the late 1980s, and, as a result, during the 1990s, U.S. refiners invested heavily in technologies that allowed the use of heavier crude oil inputs. These investments led to stronger demand for heavy crude oil, effectively raising its price and reducing the magnitude of the spread, as well as the profit potential of those investments. During the recent period of increased crude oil prices, from 2004 through 2007, the spread between light and heavy oils has again increased, reaching record levels in 2006. By January 2008, the spread had increased to $18.79, another record. In the longer term, it may well be that the relative quantities of light and heavy crude oils available on the market will continue to shift toward the heavier oils. This shift, if it continues, might still validate the financial investments made by refiners in the 1990s and encourage additional investment in refinery enhancement.

Table 1. U.S. Real Price Spread Between Light Crude Oil and Heavy Crude Oil, 1983-2007
(Dollars Per Barrel)

Year	Spread	Year	Spread
1983	8.10	1996	5.10
1984	3.97	1997	6.43
1985	3.40	1998	6.19
1986	4.07	1999	5.08
1987	2.43	2000	7.61
1988	3.49	2001	8.83
1989	4.23	2002	5.37
1990	6.59	2003	7.03
1991	9.09	2004	10.63
1992	8.06	2005	14.23
1993	5.78	2006	14.94
1994	4.49	2007	14.62
1995	3.47		

Source: Energy Information Administration, *Petroleum Marketing Monthly,* April 2008, Table 24, p. 49.

Further complications in refining economics arise from the technology of refining. Simple refineries, those whose technology is limited to a basic distillation process, produce low yields of light products. An output of 20 percent gasoline, 30 percent middle distillates and 50 percent heavy residuals, based on an input of Arabian Light crude oil, might be typical. With an investment in the most sophisticated refinery technologies, the output mix might change to as much as 60 percent gasoline, 35 percent middle distillates and 5 percent heavy residuals.

In 2007, motor gasoline earned an average refiner price of $2.18 per gallon excluding taxes, while residual fuel oil brought an average refiner price of $1.35 per gallon, net of taxes. This 83 cent per gallon price differential represents a premium of almost 61% for motor gasoline compared with residual fuel oil.[1] **Table 2** traces the value of the price differential between motor gasoline and heavy residual fuel oil. Since the mid 1980s, while the differential has shown little trend, it has shown significant volatility, this can affect expected profitability.

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[1] Energy Information Administration, "Petroleum Marketing Monthly", March 2007, Tables 35, 42. Calculation of averages by the author.

Table 2. U.S. Real Price Spread Between Motor Gasoline and Residual Fuel Oil, 1983-2007
(Cents per gallon)

Year	Spread	Year	Spread
1983	27.3	1996	29.3
1984	17.8	1997	31.3
1985	25.8	1998	24.6
1986	22.6	1999	29.1
1987	20.4	2000	39.7
1988	27.7	2001	41.0
1989	29.4	2002	29.8
1990	37.2	2003	34.1
1991	38.5	2004	60.7
1992	36.9	2005	70.0
1993	33.3	2006	83.3
1994	28.2	2007	83.2
1995	26.3		

Source: Energy Information Administration, *Petroleum Marketing Monthly*, April 2008, Table 4, p. 13.

The most advantageous market position for a complex refinery that has invested in the capability to produce a light product mix from a heavy crude input is a large price spread between light and heavy crude and also a large spread between light and heavy products. In that environment, similar to that observed in 2007, a refiner can buy heavy crude to minimize direct input costs and sell a light product mix at relatively high prices to enhance the gross margin per barrel.

The potential for economic gain represented by these two price spreads form the incentive for investing in more complex processing units in the refining process. While these units enhance economic performance, they require substantial capital investment, usually billions of dollars. In 2005, refinery capital expenditures by the Financial Reporting System (FRS) companies in the United States totaled $15 billion, up from $8.1 billion in 2004, likely reflecting the high returns earned by refiners in 2004 as well as other factors.[2] However, in 2006 refinery investment declined to $11 billion, a decline of 27%, when compared to 2005. Additionally, $5.7 billion was spent by the FRS companies in foreign refinery capital expenditures in 2006, an

[2] Energy Information Administration, *Performance Profiles of Major Energy Producers 2006*, December 2007, Table 16, Data and Charts.

increase of 88%.[3] Not all of this amount was for technological improvements or capacity expansion; environmental based investment is also included.[4]

An additional factor in refining economics is crude oil sulfur content, defined to also include the presence of heavy metals and contaminants. Low sulfur crude oil is said to be "sweet" while crude oil with a high sulfur content is said to be "sour." Low sulfur crude oil sells at a premium compared to higher sulfur crude oil, because substantial investment must be made at the refinery to reduce the sulfur content of the product mix. These two factors, crude oil density and sulfur content, taken together, determine the quality differential in crude oil prices. At any point in time, refiners strive to run an optimal mix of crude oils through their refineries. The optimal mix depends on the state of the refineries' equipment and technology, the desired output product mix, and the price spreads on available crude oils and products. In the longer term, the refiner must decide whether to continue to invest in new technologies as they become available, based on expected future values of these factors.

Defining Profitability

Measures of economic performance in the refining industry usually begin with the *gross margin*. The gross margin is defined as the difference between the wholesale composite product price and the composite refiner acquisition cost of crude oil. Both the product price and the acquisition cost of crude oil must be composites, or weighted averages, because they reflect the multi-product nature of refinery output as well as the multi-grade character of the crude oils used as refinery inputs. The gross margin is a simple, first approach to refinery profitability. It is computed as the total revenues from product sales minus the cost of the largest single input in refinery operations, crude oil. However, other inputs are used and they too generate costs, which leads to the *net margin*. The net margin is defined as the gross margin minus petroleum product marketing costs, internal energy costs and other operating costs. Both margins are usually expressed on a per barrel basis.

Over time, crude oil prices have been volatile, reflecting international political and economic events. Both margins normally respond inversely to movements in the price of crude oil. Other things held equal, an increase in crude oil prices would reduce a positive margin and a decline in the price of oil would expand the margin. Of course, other things are rarely equal. Changes in the price of crude oil may be passed on to consumers of petroleum products. However, refiners' ability to pass on price increases and maintain sales volumes may not be equal for each component of the product mix produced by the refinery. As a result, in practice, margins may

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[3] Energy Information Administration, *Performance Profiles of Major Energy Producers, 2006*, December 2007, Table 16, Data and Charts.

[4] The FRS companies are those major energy companies that report to the Energy Information Administration's Financial Reporting System (FRS). To be included as a major energy company the firm must satisfy at least one of the following: control at least 1% of U.S. crude oil production or reserves, control at least 1% of U.S. natural gas production or reserves, or control at least 1% of U.S. crude oil distillation capacity or product sales. In 2001 the FRS companies share of refined product output was 85%.

increase or decrease when the price of oil increases. Additionally, in some cases, the event which accounted for the change in crude oil prices might itself alter specific product demand levels. For example, when expectations concerning the onset of war in Iraq drove up crude oil prices, they also reduced the demand for air travel, and hence, jet fuel. Lower demand for air travel made it difficult for refiners to pass on cost increases of crude oil while maintaining sales volumes for jet fuel.

As a result of these factors, margins are not stable, or even predictable, during periods of crude oil price volatility. The outcome tends to depend on the nature and magnitude of the crude oil price change as well as the level of demand in the product markets. Over time, persistently low margins may have important consequences for the industry. Low margins may lead to reduced refinery investment which ultimately can lead to constrained domestic capacity and higher product prices. But low margins also put pressure on refiners to reduce operating costs and spread fixed costs over larger production runs in an effort to enhance margins.

The relationships between crude oil quality, product price mix, and technological improvement make capital investment management important to the refining industry. In refining, there are several competing demands for investment funds. Capacity expansion is necessary to keep pace with growing demand. Siting a new refinery is a long and expensive process. As a result, virtually all U.S. capacity expansion in the last decade or more has come from enhancing and modifying existing refineries. Technological investments can improve refinery economics by allowing refiners to use cheaper heavy, sour, crude oils as inputs and still produce a light, high value mix of products. Finally, investment must be undertaken to keep both the refinery site and the products it produces in compliance with evolving environmental standards. The issues surrounding refinery investment are covered later in this report.

The most widely used measure of economic performance in the refining industry is return on investment (ROI).[5] As with the gross and net margins, assessing this measure requires care. First, refining returns are usually reported together with returns from marketing, largely determined by motor vehicle gasoline retail sales. Marketing net income can also be affected by credit card business performance and convenience store profits, neither of which is directly associated with the core business of refining petroleum products. Second, depending on accounting procedures and transfer pricing rules, an integrated oil company might report profit as earned in various business activities of the company, contrasted to a company whose only business is refining. Third, depreciation reduces the net value of assets over time creating an upward bias in ROI over time for any specified level of net income. Fourth, business strategy decisions, such as whether to distribute products at the retail level through company-owned service stations, or through franchises, can alter the measured ROI by affecting the invested capital base.

[5] The EIA in compiling FRS data defines return on investment as net income earned by the U.S. marketing/refining line of business (excluding unallocated items, mainly interest expense) as a percentage of net fixed assets involved in U.S. refining and marketing.

Performance of the Refining Industry

Table 3 provides historical data on refining margins for U.S. major refining firms in the FRS survey. Net margins have generally increased since the late 1990s, except for a sharp decline in 2002. The relationship between the net and gross margins was variable. For most of the year-to-year changes, the two margins track each other, but in 1992-1993, and again in 1997-1998, and again in 2003-2004, the gross margin decreased while the net margin increased. Net margins recovered in 2003 from the poor performance of 2002. Refining margins reached record highs in 2005 and remained high into 2007.

Table 3. Refining Margins of U.S. Major Oil Refiners, 1993-2006

(inflation adjusted dollars per barrel)

Year	Gross Margin	Net Margin
1993	8.63	0.91
1994	7.46	0.89
1995	6.77	0.60
1996	7.80	1.05
1997	8.01	1.74
1998	7.08	1.77
1999	6.30	1.27
2000	7.95	2.51
2001	8.60	2.99
2002	6.89	0.21
2003	8.36	2.18
2004	8.05	2.56
2005	10.18	3.62
2006	12.10	5.29

Source: Energy Information Administration, *The U.S. Petroleum and Gasoline Marketing Industry*, Table 5, updated August 2004, and *Performance Profiles of Major Energy Producers 2006,* Table 14, Data and Charts. Margin data are expressed in terms of 2005 dollars (price adjusted) and on the basis of dollars per barrel, where a barrel equals 42 gallons.

Two factors, which reflect refinery economics, emerge from the data underlying these margins. First, general operating costs declined by about 50 percent over the period. The refining industry has exerted significant effort in controlling cost and enhancing efficiency. Second, energy costs related to the production process within the refineries have declined. This is the result of significant effort by the refining industry to harness waste energy and apply it to productive purpose in the interest of reducing costs. For most of the period, the combination of volatile prices for crude oil and refined products offset the increases in efficiency implemented at refineries yielding low and volatile margins. After 2002, the financial performance of the industry was enhanced by the rising petroleum product prices in the wake of the war in Iraq, demand growth in China and other consuming nations, and the shortages that resulted from refinery closures in the aftermath of hurricane Katrina.

Table 4 shows the mix of U.S. refinery outputs through 2006. Over-all output increased, but not uniformly across the product lines. Motor gasoline output increased through 2006, but was supplemented with imports of both finished gasoline as well as blend stocks, to meet demand. Distillate fuel output, including diesel fuel and home heating oil, also increased. Jet fuel output was a relatively stable component of output, while residual fuel oils, the heavy component of the product mix, declined.

Table 4. U.S. Refinery Output,1991-2006

(millions of barrels per day)

Year	Motor Gasoline	Jet Fuel	Distillate Fuel Oil	Residual Fuel Oil	Other Products	Total
1991	6.97	1.44	2.96	0.93	2.96	15.26
1992	7.05	1.40	2.97	0.89	3.09	15.40
1993	7.30	1.42	3.13	0.83	3.11	15.79
1994	7.18	1.45	3.20	0.83	3.13	15.79
1995	7.46	1.42	3.15	0.78	3.96	15.99
1996	7.56	1.51	3.32	0.73	3.20	16.32
1997	7.74	1.55	3.39	0.71	3.37	16.76
1998	7.89	1.53	3.42	0.76	3.43	17.03
1999	7.93	1.56	3.40	0.70	3.40	16.99
2000	7.95	1.61	3.58	0.70	3.40	17.24
2001	8.02	1.53	3.69	0.72	3.32	17.28
2002	8.18	1.51	3.59	0.60	4.59	17.27
2003	8.19	1.49	3.71	0.66	3.44	17.49
2004	8.26	1.55	3.81	0.65	3.54	17.81
2005	8.31	1.55	3.95	0.63	3.45	17.71
2006	8.32	1.48	4.04	0.63	3.43	17.91

Source: Energy Information Administration, *Annual Energy Review 2006*, Table 5.8, p. 139.

In 2004, refiners experienced a market characterized by increasing demand for most products and increasing prices for refined products, along with rising prices for crude oil. The potential for instability in crude oil supplies began to play a role in late 2003, and affected the market even more in 2004, through 2006, continuing into 2008. Crude oil prices, as measured by the composite refiner acquisition cost, began 2004 at $30.93 and ended the year at $36.60, with an average price of $36.98, reflecting concerns of the effects of war with Iraq, growing world demand, and instability in other oil producing parts of the world.[6] While motor gasoline demand for 2004 increased by about 1%, the price of gasoline increased by about 24%. Jet fuel demand increased by about 4% and the price of jet fuel rose by almost 38%. Distillates demand increased by about 3% while the price increased by about 24%. Residual demand decreased by about 1%, but the average price increased by about 6%. Overall, refined product revenues for the FRS companies increased by about 26% from 2004 to 2005 and total refined product costs rose by almost 21%.

Data for 2005 and 2006 suggest a much stronger financial performance for the refining industry. Crude oil prices, based on the refiner's average composite acquisition cost, averaged over $50 per barrel in 2005, and over $60 per barrel in 2006. This led to dramatic spikes in motor gasoline prices and other petroleum product prices. The airline industry has continued to show weak demand for jet fuel, but the cold winter periods increased the demand for heating oil, and diesel fuel demand continued to increase. In the short term, the demand for most petroleum products appears to be relatively inelastic with respect to price, meaning that the rising cost of crude oil can be passed on to consumers with little loss in sales volume yielding high net income for refiners when oil prices are high.[7]

Table 5 provides an overview of profitability for the refining and marketing sectors of the FRS's companies, measured by ROI. The values for ROI are complicated by the joint reporting of refining and marketing as noted earlier in this report. These two sectors have different capital intensities and different age profiles for their capital stocks leading to differing values of invested capital, net of depreciation. The data shown in **Table 5** are somewhat at odds with other measures of industry activity, especially those related to capital investment. Even though ROI has become negative twice in the data set, production rates and industry capacity continue to expand, suggesting that an incentive for capital investment exists. How might this behavior be explained? For the integrated oil companies, even though profit rates might have been low and volatile in refining and marketing, it is possible that the firm as a whole made adequate returns from other parts of the business, notably, the production of crude oil. However, this explanation is not consistent with the profit center business model the industry appears to be adopting. For the non-integrated oil refiners who constitute a larger component of the industry since the wave of merger and acquisition activity of the late 1990s, this explanation is not applicable. The data in the **Table 5** indicate that in 2000, ROI in domestic refining and marketing was 9.6%, rising to 14.5% for 2001, an increase in the rate of return of over 50%. The declining margins of 2002 left the ROI in the negative range for that year, the first negative returns since 1992. For 2003, the FRS companies

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[6] Petroleum price data from the Energy Information Administration, *Petroleum Supply Monthly,* Table 1, Crude Oil Prices, November, 2003. The prices reported by the EIA in this table are the composite refiner acquisition price of crude oil which is a weighted average of the prices refiners paid for domestic as well as imported crude oil.

[7] Economists define demand to be inelastic when a specified change in price, say a 1% increase, yields a decline in quantity demanded of less than one percent. Petroleum product demand is more elastic in the longer term, as consumers are more able to adjust their decisions to the higher prices.

domestic ROI from refining and marketing rose to 9.3%, setting the stage for the even higher returns earned in 2004 through 2006.[8]

Table 5. Domestic Refining/Marketing Return on Investment for FRS Companies, 1991-2006

Year	Percent Return on Investment
1991	1.95 %
1992	-0.44 %
1993	3.38 %
1994	3.56 %
1995	1.00 %
1996	4.36 %
1997	6.59 %
1998	7.90 %
1999	6.54 %
2000	9.64 %
2001	14.46%
2002	-1.70%
2003	9.30%
2004	18.60 %
2005	23.50 %
2006	25.60%

Source: Energy Information Administration, *Performance Profiles of the Major Energy Producers 2006*, December 2007, Figure 6, Data and Charts.

The American Petroleum Institute computes statistics comparing the profitability, based on ROI, in oil and gas production and refining and marketing, to the returns earned by the Standard and Poor's (S&P) Industrials, which they use as a proxy for average returns to American industry. The American Petroleum Institute found that the 2001 performance of the refining/marketing sector, 14.4%, represented one of the few times that this sector outperformed both the S&P Industrials as well as the oil and gas production sector. In 2001, the S&P Industrials earned 7% and oil and gas production earned 13.1%. The averages over the past five and ten years tell a different story, however. Ten year average returns for the S&P Industrials were 11.7% and the five year average was 14.3%. These figures compare with refining/marketing average returns of 5.4% and 9.1% over the same periods.

[8] Energy Information Administration, *Performance Profiles of Major Energy Producers*, March 2005, Table B.8, p. 75.

Comparable average rates of return for oil and gas production were 8.4% and 10.3%.[9] **Table 6** shows that production capacity and capacity utilization are less volatile than the returns earned by the industry and show relatively steady incremental increases over the period.

Table 6. Refinery Capacity and Utilization, 1991-2006

	Operable Refineries		
Year	Number	Capacity (thousand of barrels per day)	Utilization (percent)
1991	202	15,707	86.0
1992	199	15,460	87.9
1993	187	15,143	91.5
1994	179	15,150	92.6
1995	175	15,346	92.0
1996	170	15,239	94.1
1997	164	15,594	95.2
1998	163	15,802	95.6
1999	159	16,282	95.6
2000	158	16,512	92.6
2001	155	16,582	92.6
2002	153	16,744	90.2
2003	149	16,748	92.6
2004	149	16,794	93.0
2005	148	17,196	90.6
2006	149	17,339	89.7

Source: Adapted from Energy Information Administration, *Annual Energy Review,* 2006, Table 5.9, p. 141.

Domestic refining capacity has generally increased incrementally since 1993, with total growth of about 15%. Refinery inputs have increased by approximately 11% over the period, with the slack being picked up by capacity utilization, which ranged from a low of 87.9% to a high of 95.6% during the period, as well as refinery gain. High capacity utilization rates leave a slim margin available to meet any increase in demand, raising, at least the potential, of market disruptions, either shortages or price spikes, in the retail market. High utilization rates also increase potential system unreliability due to stress, damage, and difficulty in scheduling down time for maintenance, repairs, and investment activities.

[9] Michael A. Lobue, *Challenges Facing U.S. Refiners*, Presentation at NEMS/AEO Conference, March 18, 2003.

While the picture of low and volatile returns might be considered somewhat inconsistent with steady capacity growth and high capacity utilization rates, one measure of return, refining/marketing net income, might be helpful in understanding the data. **Table 7** shows net income data for the FRS companies from 1995 to 2006.

Table 7. U.S. Refining/Marketing Net Income, 1995-2005

(million dollars)

Year	Net Income	Yearly Growth (percent)
1995	508	
1996	2,251	343
1997	3,106	38
1998	5,932	91
1999	4,883	-18
2000	7,659	57
2001	11,951	56
2002	-1,350	-119
2003	7,434	650
2004	15,197	105
2005	20,963	38
2006	24,313	16

Source: Energy Information Administration, *Performance Profiles of the Major Energy Producers*, 2005 and 2006.

Net income increased every year except 1999 and 2002. The year-to-year changes in net income indicate substantial volatility; however, most of it was favorable to the industry. While the change from 1995 to 1996 was a gain of over 340%, the change from 2001 to 2002 represented a decline of almost 120%, associated with a $1.3 billion loss for the sector. The total number of dollars earned rose from $508 million in 1995 to $11.9 billion in 2001, a twenty fold increase, before turning into a loss in 2002. This increase in cash flow from the refining sector could account for much of the interest the industry has shown in acquiring, investing in, and operating refineries in the face of low rates of return on investment. Net income declined sharply in 2002, falling to a loss of $1.35 billion for the FRS major energy firms. Data for 2003 show a recovery in net income, with $10.2 billion being earned from refining and marketing by the FRS firms. By 2006, net income from refining and marketing had more than tripled compared to 2003.

Changing Structure of U.S. Refining Industry

The refining industry grew from 1973 to 1981. In 1973, there were 268 refineries with a capacity of 13.64 million barrels per day in the U.S., and by 1981, there were 324 refineries with a capacity of 18.62 million barrels per day. As shown in **Table 6**, by 2006 the number of refineries had declined to 149 with a capacity of 17.3 million barrels per day. Over the period 1981 to 2006, the number of refineries declined by over 50% while the total capacity of the sector declined by about 8%. Ownership of refining assets has changed as well. **Table 8** shows the top twenty U.S. refiners, rated by capacity. Several observations can be made about this table. First, in 1980, ownership of refineries was largely held by the major, integrated U.S. oil companies. In 2006, significant foreign ownership existed, including British Petroleum, PLC, the fourth largest refiner, and PDV America, a subsidiary of the Venezuelan national oil company. Second, the period since 1981 has seen significant merger and acquisition activity within the U.S. oil industry as oil companies sought to acquire expanded crude oil reserves as well as other assets through acquisition and merger with other firms. As a result of mergers, acquisitions, and corporate strategy, the ownership of many specific refineries has changed hands, even though the total capacity of the corporate entity has remained relatively stable. For example, the Bayway refinery in Linden, New Jersey, with a current capacity of 238,000 barrels per day was owned by ExxonMobil, but is now owned by ConocoPhillips; Conoco and Phillips Petroleum were separate companies in 2001. Third, the industry now has significant capacity operated by firms that are not integrated oil companies at all, but specialize in only a part of the petroleum supply chain. Fourth, specific joint venture organizations, (e.g., Motiva Enterprises) have been created to engage specifically in refining. Joint ventures have become common because they allow for significant cost and risk reductions through asset sharing and rationalization, but do not require the financial and institutional stresses of a more direct union through merger or acquisition.

Table 8. Top Twenty U.S. Refiners, 1980-2005

(thousand barrels per day)

1980		2006	
Company	Capacity	Company	Capacity
Exxon	1,557	Valero	2,219
Standard of California	1,383	ExxonMobil	1,862
Standard of Illinois	1,238	ConocoPhillips	1,778
Shell	1,123	BP PLC	1,460
Texaco	1,059	Chevron	1,011
Gulf	949	Marathon Oil	974
Mobil	835	Sunoco	903
Atlantic Richfield	811	PDV America	812
Sun	521	Koch Industries	777
Marathon	513	Motiva Enterprises	762
Union	490	Tesoro Corp	567
Ashland	462	Royal Dutch Shell	532
Standard of Ohio	452	WRB Refining LLC	452
Conoco	448	Deer Park Refining	333
Phillips	397	Lyondell Chemical	270
Cities Service	291	Total SA	232
Union Pacific	283	Chalmette Refining	193
Coastal	278	Sinclair Oil Corp	161
Getty	261	Frontier Oil Refining	154
Tosco	260	Murphy Oil Corp	154

Source: American Petroleum Institute, Basic Petroleum Data Book, Section VIII, Table 11, October 2007.

The characteristics of the refining industry suggest that significant structural change has occurred over the past twenty years. Much of that change can be attributed to the forces of economic rationalization rather than to economic decline. However, even if it can be determined that the industrial structure today is stronger than that of the past, it still may be that the industry is not fully capable of meeting the challenges of the future.

One of the most obvious structural changes undergone by the industry is the number and size of available refineries. Clearly the number of refineries has sharply decreased. Three factors play a role in explaining the decline: the end of government regulation, technological developments, and economic reality.

The Emergency Petroleum Allocation Act of 1973 (P.L. 93-159) attempted to ensure an equitable distribution of petroleum products, establish equitable prices, and preserve the independent sector of the oil industry at a time when oil market relationships were in disarray after the oil embargo of 1973. Through its Supplier-Purchaser Rule, the Buy-Sell Program, and the Crude Oil Entitlement Program, all of which tried to protect small, independent refiners, the act had the effect of increasing the incentive to build and own small refineries, many of which were inefficient. Between 1973 and 1981 there was a net expansion of 43 refineries (75 newly constructed, 32 old units closed). All but two of the new refineries had an input capacity of less than 50,000 barrels per day, which was the average refinery size in 1973. The average capacity of the new refineries that came on line over the period was 14,900 barrels per day. The utilization rate of the refinery sector declined during the expansion phase. In 1973, the capacity utilization rate was 93.9%, but by 1981 it had fallen to 68.6%. The industry was characterized by idle capacity, too many producers, and many refineries too small to benefit from economies of scale. In addition, many of the small refineries were very simple distillation facilities unsuited to produce the product slate required by the market and environmental requirements. As a result, a good portion of the output of these facilities was only suited to serve as feedstock for larger, technically sophisticated refineries. President Reagan ordered the elimination of the allocation programs that favored the small refiners in 1981, and since then the industry has responded to market forces.[10]

Technological and economic rationales for the decline in the number of refineries are linked. The market for petroleum products has become heavily skewed toward a lighter product mix, mainly gasoline, to serve demand from the transportation sector. Lighter product mixes are primarily produced by adding additional technical processing units downstream from the basic distillation procedure. The technology and economics of the industry suggest that investment in those downstream facilities is only rational for large scale plants, due to significant economies of scale. The net effect of these factors may be that the smaller number of larger refineries operating in 2006 are economically and technologically better prepared to meet the requirements of the market than the earlier structure, even with far fewer refineries and a smaller total capacity.

Although foreign ownership of refineries on U.S. soil has increased, this may be the result of a continuing process of internationalization of the oil industry. U.S. major oil companies have long had a presence in all aspects of the industry around the world. They have brought quality products as well as technological expertise and investment to many countries. Today, with the largest oil companies even more international in character than in the past, the United States is receiving a share of the products, technology and investment that U.S. oil companies provided, and continue to provide, around the world. A threat to U.S. supply security related to foreign ownership might be possible if the owner of the refineries was controlled by foreign governments with oil supply as well as hostile intentions to the United States, but this does not seem to be the case in the present pattern of ownership.

Beyond the number of firms and their productive capacity, and the extent of foreign ownership, another important part of the structure of the refining industry is the degree of concentration. Concentration refers to the proportion of the total market accounted for by the largest firms. In petroleum refining, concentration can be determined on the national level and on the regional level. The results are quite different. The largest national refining companies are not necessarily the most

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[10] Energy Information Administration, *The U.S. Petroleum Refining Industry in the 1980's*, October, 1990, p. 6.

important refiners in any given region, and the most important regional refiners are not necessarily the national leaders.[11] **Table 9** shows these relationships for the Petroleum Administration Defense Districts (PADDs).[12]

Table 9. Refining Concentration by PADD

(percentages)

	Top 5 Refiners Share of Capacity by PADD					
	US	**PADD1**	**PADD2**	**PADD3**	**PADD4**	**PADD5**
1/1/06	49	87	63	48	51	71
1/1/02	44	90	56	53	62	69
1/1/96	32	71	48	40	59	61
	National Top 5 Refiners Share of Capacity by PADD					
	US	**PADD1**	**PADD2**	**PADD3**	**PADD4**	**PADD5**
1/1/06	49	49	47	52	27	57
1/1/02	44	27	33	39	20	56
1/1/96	32	19	28	25	27	28

Note: PADD 1 includes Connecticut, Delaware, District of Columbia, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, and West Virginia. PADD 2 includes Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin. PADD3 includes Alabama, Arkansas, Louisiana, Mississippi, New Mexico, and Texas. PADD4 includes Colorado, Idaho, Montana, Utah, and Wyoming. PADD5 includes Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington.
Source: "Refining Concentration and Industry Dynamics," Petroleum Industry Research Foundation, Inc., N.Y., April 2002. p. 2-4, Energy Information Administration, [http://www.eia.doe.gov].

The table shows that, on the national level, the share of the industry held by the largest five firms has increased from 32% in 1996 to 44% in 2002 and to 49% by 2006. However, the top five firms were different in 2006 than in 1996. The top section of the table shows that concentration is generally higher on a regional level than on the national level. The bottom part of the table reveals, however, that the firms that dominate refining at the national level are not necessarily the same firms that hold the largest shares of refining capacity in the PADDs.

PADD 3, which is the Gulf Coast, has the lowest regional concentration, 48%. This region also has the second largest share held by the leading national refiners, and the share of the national leaders has increased by 27% since 1996. However, PADD 3 production is far greater than regional demand and pipelines connect the major Gulf Coast refiners to other major consumption markets. As a result, refiners

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[11] The information on industry concentration in the PADDs draws from a report by the Petroleum Industry Research Foundation, Inc., *Refining Concentration and Industry Dynamics*, April 2002.

[12] PADD is an acronym for Petroleum Administration for Defense Districts. The 50 states and the District of Columbia were divided into five geographic districts in 1950.

in this region compete not only among themselves to satisfy local demand, but against refiners in other PADDs.

PADD 5, the West Coast, presents unique features. The share held by the top five regional refiners is over 70%, and the share held by the largest national refiners is 57%. Several features also isolate the region from the rest of the nation. First, there is no major finished product pipeline between PADD 5 and the rest of the country. This effectively isolates the market from competition from other areas, especially PADD 3, with its large refineries that compete in other regions of the nation. Second, PADD 5 is characterized by the CARB (California Air Resources Board) gasoline, a unique, state-mandated formulation which adds to the relative isolation of this market by making gasoline from other areas generally unsuitable in large portions of PADD 5. As a result, the Federal Trade Commission has been especially active in requiring divestiture during mergers and acquisitions in this PADD to assure continued competition. For example, both the Exxon Mobil and the Chevron Texaco mergers required divestiture of PADD 5 refining assets by at least one of the merging firms. Many other mergers, acquisitions, and joint ventures in PADD 5 only achieved Federal Trade Commission approval after divestiture. In some cases, these actions brought new competitors into the region, as when BP acquired ARCO's refineries.

PADD 1, the East Coast, could be characterized as an open market. While it is connected, via pipeline, to the large refineries on the Gulf Coast, it is also accessible to imports from overseas. Within the region the largest five national refiners have a 49% share of the market, while the leading refiner, Sunoco, has approximately a 5% share of the national market.

PADD 4, the Rocky Mountain area, is again, similar to PADD 5, an isolated market, but in this case the top five regional refiners hold a 51% share while the national leaders hold a 27% share.[13] PADD 2, the Midwest, has had a relatively stable pattern of market share, and it shares with PADD 1 the characteristic of being an open market. It is tied by pipeline to PADD 3, which supplies the region with approximately 20% of its supplies.

In summary, even though there has been significant merger and acquisition activity in the refining sector, the data for the period 1996 to 2001 do not indicate sharply different patterns of industry concentration at the national or regional levels, while concentration has increased from 2002 to 2006. Because of the economic rationalization and concentration on core competencies that these mergers and acquisitions seem to imply, the firms that remain in the industry might well be better positioned for market competition.

[13] As a result of the Conoco Phillips merger the share of Conoco, which was the largest regional refiner, grew to 25% from 21%. This caused the top five share to rise to 66%.

Challenges Facing the Refining Industry

Historically, the major oil companies treated the refining activity as an integrated part of a production stream that ran from exploration to final retail sale of petroleum products. One implication of this business model was that the refining sector was not necessarily considered to be a stand-alone profit center. Refinery profits or losses could be integrated with other parts of the business. This model has changed in the 2000s to one requiring each component of the supply chain to pull its own weight, or generate sufficient profitability, to satisfy investors' requirements for return on invested capital. This changed business model results, at least partly, from the entrance into the refining market of large, independent companies whose major interest in the petroleum industry is downstream refining and marketing.[14]

Given the place of refined products in the economy, earning sufficient return on invested capital in the refining industry should be possible. After all, the industry's output is largely characterized by products that are essential to modern life: motor gasoline, diesel fuel, jet fuel, and other products whose demand has generally been growing. The industry has also made significant progress in controlling operating costs, although the most significant cost, that of crude oil, is beyond its control. The basic challenge to the industry is to maintain a competitive ROI at the same time that adequate capital is allocated to technological improvements, refinery expansion is undertaken to meet forecasted increases in demand, and investments to keep refinery products and sites consistent with environmental laws and regulations are made.[15] If the refining industry is successful in meeting this challenge, a more stable market will likely prevail. If industry is unsuccessful in meeting this challenge the market is more likely to experience instability, characterized by supply disruptions and price spikes, as well as an increasing dependence on foreign supplies of refined products.

Environmental Requirements

From a refiner's point of view, most environmental requirements, whether they affect product specification or site compliance, affect business operations in a similar manner. They require capital investment in additional stages, or technical processes, to be added to the refinery. The investment process begins with certification and permit approval with regulatory agencies and, ultimately, moves to design and construction at the refinery to implement the new processes. Some of the current, or expected, product specification requirements that are likely to affect refiners over the next several years include reduced sulfur content in gasoline and diesel fuels, reductions in smog-forming compounds released during handling (vapor pressure), reduced smog-forming emissions from vehicles (reformulated gasoline), reduced toxics and chemical exposure during handling and storage (methyl tertiary butyl ether (MTBE) bans), improved engine performance (drivability index), and the use

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[14] D.J. Peterson and Sergej Mahnovski, *New Forces at Work in Refining, Industry Views os Critical Business and Operations Trends*, RAND Science and Technology, 2003, p. 14.

[15] The effect of environmental requirements on industry profitability is analyzed in Energy Information Administration, *The Impact of Environmental Compliance Costs on U.S. Refining Profitability 1995-2001*, May 2003.

of non-petroleum based feedstocks (ethanol).[16] The goal in this report is not to evaluate the net benefit of any of these requirements, or environmental site requirements which form an additional set of restrictions, but to recognize that they all have a similar impact on the refining industry: they require an allocation of resources to capital investment that does not result in lower costs or increased output, and are, therefore, likely to affect the ability of the industry to meet economic performance expectations.

Capital Investment

Capital expenditures in the refining industry serve a variety of purposes. First, they may augment capacity or upgrade technological capability, either through the construction of new refineries or through the modification of existing refineries. Second, they may be required to allow both, or either, the produced products or the site itself to meet environmental requirements. Third, capital expenditures may be used for mergers and acquisitions.

As discussed earlier in this report, there has been no significant investment in new refineries in the United States in the past twenty five years. However, investment has taken place to enhance the capacity of existing facilities. Investment in capacity expansion and technology is expected to generate profits enhancing the net margin and yielding a positive ROI. Environmental investments are different. They are required to allow the refinery to stay in operation, but they yield little or no direct financial return for the refiner. They are either absorbed from profits or passed on to the consumer, or both. Since they increase the capital value of the refinery, but yield no net revenue, they can reduce the overall ROI, depending on cost pass-through to the consumer.

Capital expenditure for merger and acquisition has dominated the investment picture in the refining industry since the late 1990s. These expenditures are made for a variety of reasons, from entering or expanding a firm's presence in the industry, to rationalizing refining strategy, to production and marketing goals, or by legal directive as in conjunction with the stipulations to complete a merger or acquisition. Firms expect these expenditures also to be profitable, at least in the longer term.

Even though refining and marketing profitability has grown with the oil price increases since 2004, the profit and cash rich position of integrated oil companies and domestic refining companies may not translate into capital investment in the refining sector. The choice to invest in a new refinery is actually a decision to produce an additional barrel of refined petroleum products for the U.S. market. Growth in product demand, especially gasoline, suggests that the demand for the additional product is fairly certain.

The question remains; what is the cheapest way to provide that extra product to the market? Four possible answers exist. First, a company could decide to expand the capacity of an existing refinery. Second, a company could build a new refinery. Third, a company could decide to import the extra production into the United States.

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[16] Ibid., p. 22.

Fourth, a company could acquire the refinery of another company. The fundamental economics, as well as the market and regulatory environments, suggest that, all other things equal, construction of new refineries is not likely to be the chosen alternative.

Over the past two decades refiners have chosen to expand existing refineries in preference to new construction. The reasons are part economic and part regulatory. Economic rationales favor expansion over new construction, because the fixed cost associated with a new facility can be avoided and economies of scale at the expanded facility can be realized. Satisfying regulatory requirements for an expansion at an existing facility are likely to be less costly, less time consuming, and less subject to challenge by local groups compared to a new facility.

Given the economics of the oil market, it may remain cheaper to import extra petroleum products than to produce them in the United States. Excess capacity for gasoline that meets U.S. specifications is available in Europe and other parts of the world. Similarly, it may also be cheaper for any given company to expand its refining capacity by purchasing assets from other companies. While this strategy may improve the supply position of the acquiring firm, it does little to improve the supply position of the U.S. market as a whole.

Special circumstances may justify construction of a new facility. Such a facility is planned for construction in Arizona.[17] In the case of the Arizona facility, the refinery is positioned to supply products to the persistently tight southern California market, where high margins might be earned, using Mexican crude oil as an input. Although the permitting process for this facility is nearing completion, it has been in process for over five years.

Another new proposed U.S. refinery project is to be located in South Dakota, and produce ultra low sulfur gasoline and diesel fuel. The source of crude oil would be from Canadian oil sands, and the refinery is expected to use about 400,000 b/d of crude oil. The cost of the refinery has been estimated at between $8 and $10 billion.[18]

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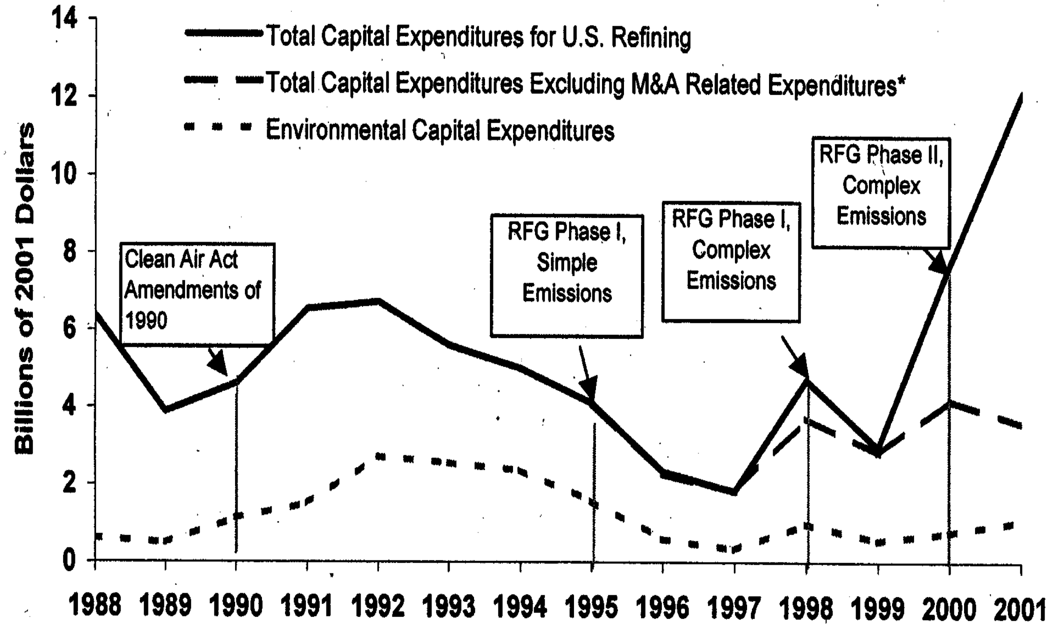
[17] Sarah Reynolds, *East County Oil Refinery Will Move*, The Yuma Sun, February 8, 2008. Available at [http://www.arizonacleanfuels.com/2008/020508_YS.htm].

[18] New York Times, *Refinery Considered for South Dakota*, June 14, 2007. Available at [http://www.nytimes.com/2007/06/14/business/14oil.html].

Figure 1. U.S. Refining Capital Expenditures for FRS Companies, 1988-2001



Source: Energy Information Administration, The Impact of Environmental Compliance Costs on U.S. Refining Profitability, May 2003, Table 6, p. 10.
*Mergers and Acquisitions.

Figure 1 shows the behavior of refining capital investment by the FRS companies since the late 1980s, isolating both environmental and merger and acquisition based expenditures. The effect of environmental requirements, specifically the Clean Air Act Amendments of 1990 (P.L. 101-549) on capital expenditures are shown in the figure. In the late 1980s capital expenditures for environmental purposes averaged $0.5 billion annually in inflation adjusted dollars. To meet the oxygenated gasoline, reduced sulfur diesel fuel, and reformulated gasoline mandates of P.L. 101-549, investment peaked at $2.7 billion in 1992 and remained above $2 billion for the following two years, in inflation adjusted dollars. According to the EIA, these environmental investments made substantial contributions to the reduced ROI of the refining industry during the period 1991 to 1995. The EIA has determined that ROI was reduced by 69% over the period as a result of the implementation of Federal environmental statutes and/or the Clean Air Act Amendments. Both Phase I and Phase II of the complex emission regulations for reformulated gasoline, in 1998 and 2000 respectively, caused increases in capital expenditures in anticipation of their effective dates. The EIA determined that ROI was reduced by 42% from 1996 to 2001 as a result of environmentally based capital expenditures.[19]

The challenge for the industry is how it responds to the next round of required environmental investments given this experience. Estimates forwarded in the 2003

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[19] The Energy Information Administration, *The Impact of Environmental Compliance Costs on U.S. Refining Profitability 1995-2001*, May, 2003, p. 1. [http://www.eia.doe.gov/emeu/perfpro/ref_pi2/refpi2.pdf]

RAND study of refiners are $4-13 billion to meet the on-road ultra low sulfur diesel requirements by 2006, and perhaps $10-15 billion additional to meet other mandates.[20] The American Petroleum Institute sees the total cost of meeting the 2006 on-road ultra low sulfur diesel requirements at $8 billion. It sees an additional $8 billion investment to meet gasoline sulfur reduction requirements.[21] The range of investment cited is large and significant uncertainty remains concerning actual values. If accurate, there could be some concern that environmentally based claims on capital expenditure might crowd out other investments. In that case, investment in capacity expansion might not be funded, even though potentially profitable. That lack of investment could drive up capacity utilization rates even higher which would likely increase the fragility of the market and make it more open to price volatility and quantity disruption.

The strength of the crowding-out argument diminishes when the rapid increase in capital expenditure shown in **Figure 1** for mergers and acquisitions from 1999 to 2001 is considered. Clearly, the ability to raise capital, either in the form of debt or equity, must have been available to the industry to fund the approximately threefold increase in investment from 1999 to 2001, much of it to finance mergers and acquisitions. The ability of the industry to manage and balance its capital investment budget between competing claims may well be an important determinant of how well the industry is able to meet increasing demand with new, environmentally compatible capacity.

Production and Growth

In its reference case forecast, the EIA projects that refined products consumed will increase from 20.7 million barrels per day in 2004 to 22.7 million barrels per day in 2015 and 26.9 million barrels per day in 2030.[22] This growth implies an average annual growth rate of 1.1% over the period. Another way of looking at the projected growth is to note that if it were to be met by domestic refining capacity, it would require capacity increments of approximately 238,000 barrels per day, per year. This would be equivalent to the production capacity of one new, large, refinery. An additional, similarly sized refinery would have to be added to the capacity base each year to meet projected market requirements. Alternatively, capacity expansion based on technological improvements would have to continue at a high rate for the 26-year period.

Set against this forecast of increasing demand is the incrementally increasing capacity of the industry, as well as the declining number of refineries. The last new refinery to open in the United States was the Petro Star refinery in Valdez, Alaska, in 1993, which had an original capacity of 38,000 barrels per day and was a simple refinery. The last refinery of significant capacity (200,000 barrels per day, or more)

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[20] D.J. Peterson and Sergej Mahnovski, *New Forces at Work in Refining, Industry Views of Critical Business and Operations Trends*, RAND Science and Technology, 2003, p. 64.

[21] Michael A. Lobue, *Challenges Facing U.S. Refiners,*NEMS/AEO Conference, March 18, 2003.

[22] Energy Information Administration, *Annual Energy Outlook, 2007,* Table A11, p. 156.

to open in the United States was the Marathon refinery in Garyville, Louisiana, which opened in 1977, more than 30 years ago.[23] With this historical record, construction of a new 400,000 barrel-per-day capacity refinery per year to meet projected demand growth would appear to be a major challenge.

Several factors come into play in the refining industry's plan to meet forecasted market requirements. Even though no new refineries were constructed during the 1990s, and the number of refineries declined, refinery capacity increased on average 1.5% per year. If projected into the future, this growth is sufficient to meet the EIA long term forecast of demand increases for refined products. These increases in capacity are due to investment in new processing units, marginal expansion (known as capacity creep) obtained through bottleneck removal, and more intensive use of existing capacity by lengthening time between maintenance and overhaul. This type of expansion ultimately could encounter diminishing returns, although the record of the industry suggests that even more capacity might be squeezed out of the existing stock of refineries.

Another key factor in maintaining production is capacity utilization. Capacity utilization rates remain high, approximately 93% in 2003, and almost 91% in 2002. The capacity utilization rate has remained above 90% every year since 1993. Excess capacity is a luxury no refiner seems anxious to support, because of its effect on profitability. This view is borne out by executives who participated in the RAND study.[24]

Imports

With capacity utilization rates near a maximum, no new refinery construction likely, and growth through capacity creep less than the growth in EIA projected demand, imports of petroleum products would seem to play an increasingly important role in the supply of refined products. Refined product imports, mostly from Canada, the Caribbean and Europe have been an important component of the total supply equation for some years. In 2006, petroleum product imports of all types, totaled about 3.5 million barrels per day, which amounted to approximately 17% of total product supplied to the U.S. market. Import dependence on refined products has averaged approximately 6% of total product supplied since 1992. However, the percentage has increased in each of the past six years. Most observers feel that there is sufficient short run capacity in the world market to expand U.S. imports, with the expansion of specific blends of motor gasoline for specific regional or state markets posing the greatest potential challenge. **Table 10** shows data from 1992 to 2006 for total petroleum product imports, as well as the most significant sector, motor gasoline, and blending components.

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[23] Data provided by the Energy Information Administration, Office of Oil and Gas, Petroleum Division by personal communication, September 12, 2003.

[24] D.J. Peterson and Sergej Mahnovski, *New Forces at Work in Refining, Industry Views of Critical Business and Operations Trends,* RAND Science and Technology, 2003, p. xv.

Table 10. Imports of Petroleum Products, 1992-2006

(thousands of barrels per day)

Year	Motor Gasoline	Blending Components	Gasoline plus Blending Components	All Product Total	All Products, Net of Gasoline, and Blending Components
1992	294	41	355	1,805	1,470
1993	247	27	274	1,833	1,559
1994	356	20	376	1,933	1,557
1995	265	48	313	1,605	1,292
1996	336	166	502	1,971	1,469
1997	309	200	509	1,936	1,427
1998	311	209	520	2,002	1,482
1999	382	217	599	2,122	1,523
2000	427	223	650	2,389	1,739
2001	454	298	752	2,543	1,791
2002	498	311	815	2,370	1,496
2003	518	367	885	2,599	1,714
2004	496	451	947	3,057	2,110
2005	604	494	1,098	3,471	2,373
2006	477	669	1,146	3,517	2,371

Source: Energy Information Administration, Annual Energy Review 2006, Table 5.3, p.129, and computations by the author.

The table shows that imports of motor gasoline and blending components began a more or less steady upward movement in 1996. Imports of these two items increased by 60% in 1996 compared to 1995, and, since then, have increased by another 128%. Over the period covered in **Table 10**, the increase in motor gasoline and blending components accounts for about 80% of the increase in the imports of all petroleum products. The total increase in petroleum product imports without motor gasoline and blending components is less than 61% over the period, while the increase in motor gasoline and blending components is 223%. Imported petroleum products other than gasoline and gasoline blending components include a wide variety of distillate fuel oils, jet fuel, liquefied petroleum gases, residual fuel oil, unfinished oils and other products.

Several difficulties could emerge as increased reliance is placed on imports. The first issue is sourcing. If worldwide economic growth continues to remain sluggish, an excess of world refining capacity could persist and the U.S. market might well continue to find product available. European sources accounted for over 50% of motor vehicle gasoline and 40% of gasoline blending component imports in 2007. Continued availability of European stocks at volumes comparable or greater than these levels may not be sustainable. Europe is undergoing a transformation of its transportation fuels mix. While its refinery capacity is largely oriented toward gasoline production due to past investment decisions, the European vehicle fleet is rapidly moving toward diesel fuel. The implication is that, until refinery conversion is completed, European refiners will have an excess supply of gasoline to sell on the world market. As a result, the long term availability of European supplies of gasoline may diminish as the U.S. demand for gasoline continues to grow. Slow growth in the Asian economies, excluding China, continues to hold back the growth of demand for gasoline in the region. Before the financial crisis in 1997, Asian gasoline growth rates were the highest in the world. Until economic recovery is complete and demand growth comparable to pre-crisis levels returns, the Asian market is also likely to have excess refining capacity. Near term sourcing of imports then, from Europe as well as Asia, seems relatively secure. In the longer term structural change in the European fuel mix and the recovery of Asian demand growth may limit available imports.

The second factor influencing the viability of increased reliance on imports is the segmented nature of the U.S. gasoline market. Gasoline in the United States is no longer a fungible, or easily transferable, product. Differing U.S., regional, and state air quality standards with respect to fuel specifications have produced a market where shortages may appear because gasoline of a particular specification is tight, even though gasoline of other specifications might be available. As the large U.S. market is divided into smaller sub-markets that demand fuels not required in other regions, or other parts of the world, it might become difficult to find refiners on the world market willing to customize production to satisfy particular U.S. demands. The result can be that spot shortages and price spikes, similar to those that occurred in Chicago in 2002 in conjunction with the elimination of MTBE as a gasoline additive. Availability, as well as price considerations, suggest that if gasoline were a standardized commodity rather than a specialized good, it would be less likely to be linked to local market instability.

A final factor regarding imports has to do with long and short run matching of demand and supply. The EIA forecast indicates a long term need for imported refined products, mainly gasoline and blending components. Recently, there has been a growing market in very short run "target of opportunity" cargoes of refined products. That is, an almost speculative market has developed in which a tanker might load a cargo without a firm buyer at a port where gasoline is available at an attractive price. The owner of the cargo then directs the tanker to the port at which the best price might be earned. On the one hand, this type of activity represents market forces directing supply to areas with high demand. On the other hand, the process may represent a somewhat opportunistic, and uncertain way of securing supplies. It is not hard to imagine a scenario where this type of supply dependency might periodically lead to market disruptions complete with shortages and price spikes.

Permits and Regulatory Uncertainty

An important concern of the refining industry is largely administrative and regulatory. As noted earlier in this report, the refining industry is working within a long term program of implementing congressionally mandated environmental standards. Some see the regulated environment as an opportunity. Some participants in the RAND study noted that regulations formed a barrier to entry into the market. The result might be higher profits, for which they cite California refiners who are faced with the most stringent set of federal, state, and local environmental regulations in the nation, and yet operate the most profitable refineries in the nation.[25] In general, however, the RAND study reports significant concern in the industry regarding the administration and implementation of the regulatory process.[26]

According to the RAND study, the best case regulatory process from the industry's point of view is one that minimizes uncertainty and maximizes flexibility. The industry's preference is to see a regulatory roadmap laid out which covered an adequately long planning horizon, say a decade. They would like to see a plan where no regulations contradict or compete with one another. They would like to see phasing in of regulations in a manner that minimizes pressure put on construction or investment timetables and plans. They would like to see a smooth, timely permitting process in which administrative delays are minimized. Industry would also prefer to have flexibility in how, technologically, to meet environmental standards.[27]

Conclusions

The petroleum refining industry forms a critical infrastructure in the U.S. economy. It provides products which allow America to move, whether by air, land, or sea, but it must accomplish this while maintaining national and regional environmental standards. The industry has demonstrated that this is possible. There has been minimal market disruption that can be traced to the refining sector, over the past twenty years. However, the EIA Annual Energy Forecast 2006 suggests that the industry is unlikely to be able to maintain this performance over the planning period to 2030 without the domestic market becoming significantly more dependent on imported motor gasolines and blending components. Increased import dependency implies the potential for both supply disruption as well as national energy security concerns.

The EIA has found that the legacy of past environmental requirements on the industry have been substantially reduced ROI. The industry has been able to absorb these lower rates of return in the past largely because of the ownership structure of the industry and the associated business model. A new market structure and business model might implicitly require better economic performance from the industry. To the extent that the performance of ROI negatively affects decisions concerning continued capacity expansion and technological investment in the industry, the effect of the structural changes in the industry might have national energy policy implications.

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[25] D.J. Peterson and Sergej Mahnovski, *New Forces at Work in Refining*, RAND Science and Technology, p. 85.

[26] Ibid., p. 70-79.

[27] Ibid.