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Photo credits: Cover and Rodeo Unicracker (page 13) photography courtesy of ConocoPhillips.
Market Overview by Purvin & Gertz, Inc.

Refining industry begins a slow recovery in 2010

Pace of recovery in oil refining profitability will be driven by product demand growth and rationalization of weak capacity

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After several years of strong margins and robust global demand growth, the refining industry persevered through the market lows of 2009. Significant new refinery capacity additions combined with a dramatic fall in demand for refined products has created a significant near-term oversupply situation. The supply situation is being further eroded by the requirement to blend increasing volumes of ethanol and biodiesel into products, thereby reducing crude oil processing requirements. This article highlights some of the key conclusions from the recent update of Purvin & Gertz’s Global Petroleum Market Outlook.

Economic outlook. The recent global recession has had a significant medium-term impact on all countries, but over the next 20 years, we expect world economic growth to average roughly 3.5%. Growth will be higher in the developing countries than in the mature, developed regions such as Europe and North America. Strongly divergent economic growth patterns in the developing vs. developed countries result in equally strong divergence in petroleum demand growth. Demand in the developing countries will surpass Organization for Economic Co-operation and Development (OECD) demand by 2015, and virtually all future growth will be outside of the OECD countries (North America, Europe, and Japan). China alone is expected to account for over 40% of non-OECD demand growth through 2030.

Refined product demand. The challenge to supply energy to a growing global population of expanding financial means is huge. Energy requirements will remain high in terms of consumption per capita even as major advances in energy efficiency are deployed. The large potential for global demand growth underpins our view of higher future petroleum prices. Energy efficiency gains will be driven by higher prices and in part by implementation of greenhouse gas initiatives in major economies.

Petroleum will continue to supply over 92% of the energy demand in the transportation sector through 2030. Diesel, jet fuel and residual fuel oil are expected to be the fastest growing transportation fuels. Most of the gasoline demand growth will be in developing countries. Use of natural gas and electricity in the transportation sector will continue to expand in niche applications such as mass transit and local fleet vehicles, but will not become significant private transport fuel alternatives until after 2020.

Petroleum will supply an increasing share of the energy demand in the other sectors of the world economy. Most of this increase will come from higher use of ethane, liquefied petroleum gas (LPG) and naphtha for petrochemicals manufacturing in the developing countries of Asia and the Middle East. Another notable increase in demand will come from increased use of residual fuel oil for power generation in the Middle East.

Shortly after 2015, demand in the non-OECD countries is expected to surpass demand in the OECD countries (Fig. 1). Refined product demand in OECD countries suffered a steep drop in 2008–2009 to 41.4 million (MMbpd) in 2009, and the forecast demand growth of only 0.2% per year through 2030 will keep demand below the 2005 peak level. Demand in non-OECD countries will grow rapidly from the current level of 36.0 MMbpd in 2009 to 56.8 MMbpd in 2030, a growth rate of 2.2%. Of the expected 20.8 MMbpd increase, China alone will account for over 43% of this increase, or 9.1 MMbpd.

Over the last few years, gasoline markets in the Atlantic Basin have undergone profound changes both in terms of demand trends and the introduction of biofuels. The widespread introduction of ethanol into the US gasoline supply initially replaced methyl tertiary butyl ether (MTBE), but more recently, ethanol has added significantly to the domestic gasoline supply. The increased blending of ethanol as required by the Renewable Fuels Standard regulations and decreased gasoline demand in response to record high consumer prices resulted in a significant decrease in the consumption of petroleum-based gasoline components in the US in 2008 and 2009.

Fig. 1. Non-OECD refined product demand—1990 to 2030.
Global demand for diesel is growing much faster than gasoline demand. Key factors are dieselization of the personal vehicle fleet in Europe, growing penetration of ethanol into gasoline, improving vehicle efficiency and higher sustained prices affecting personal vehicle use. Diesel demand in the Atlantic Basin caught up to gasoline demand in 2008, and is poised to return to growth while gasoline stagnates. Refiners will be pressed to increase diesel output and reduce gasoline yield, and Europe's structural surplus of gasoline will persist.

Tighter diesel sulfur specifications are propagating throughout the world after having been implemented in Europe, Japan and North America. In order to improve air quality, many of the world's megacities (i.e., Beijing, Shanghai, Mexico City, São Paulo and Mumbai) now require clean burning diesel and gasoline with sulfur levels below 500 ppm. Over the next 5 to 10 years, we expect that most countries will begin to adopt these requirements and some will go even further to require ultra-low sulfur diesel (ULSD) and gasoline. Several states in the US are planning to tighten heating oil sulfur specifications by the end of this decade. Combined, these actions will have the eventual effect of requiring additional hydroprocessing capacity in refineries.

Bunker fuel is the only growth market for residual fuel oil, but annual growth varies with the demand for petroleum, containerized cargo and minerals. Residual fuel use for power generation and other stationary applications has been in decline for many years as increasing supplies of natural gas have gained market share based on pricing and/or environmental benefits. One exception is the Middle East where Purvin & Gertz expects a significant increase in the use of residual fuel oil for water desalination and electric power generation.

New ship bunker fuel quality requirements adopted by the International Maritime Organization (IMO) will impact the refining industry as well as the shipping and bunker fuel supply industries. In the near term, the most significant impact will be the fuel substitution (diesel vs. residual fuel oil) requirements of the IMO regulations for the Environmental Control Areas (ECAs) in North Europe and North America.

The global bunker quality requirement of 0.5% sulfur fuel in 2020/2025 is a complicated inter-industry topic that was addressed by Purvin & Gertz in a separate comprehensive study titled Residual Fuel Market Outlook. How the shipping industries respond to the changes in regional and global bunker sulfur fuel requirements and to what degree onboard scrubber technology is adopted are key factors affecting the bunker fuel outlook. Increased carbon emissions from these new specification requirements must also be considered. Investment in large scale residue hydroprocessing would be a major shift in refining strategy and the displacement of 4 MMbpd of residual bunker demand to distillate fuel would require major additional refinery conversion investments. At the same time, the suitability, acceptance and adoption of onboard scrubbers is not a foregone conclusion.

Crude oil supply. Crude oil production from non-OPEC countries is not expected to expand fast enough to keep pace with demand growth after the economic recovery is well underway. Strong growth in crude production from Brazil, Russia, Kazakhstan, Azerbaijan, and a few other non-OPEC countries will barely keep production levels rising for this group of countries through most of this decade, but an eventual decline is forecast unless some unexpected large discoveries are made and developed. Incremental crude oil production will come mostly from OPEC members beginning this year. Increasing OPEC market share will allow the cartel to maintain long-term price levels above $70/bbl.

Growth in production of heavy crude oils has slowed markedly over the last five years. Significant declines were seen in Mexico and Venezuela, but increasing production from other countries such as Angola, Brazil, Colombia and Sudan has provided a partial offset. Large investments in refinery conversion capacity since 2000 allowed refiners to increase the percentage of heavy crude runs from 15% in 2000 to about 19% in 2005. Heavy crude's share has not increased since 2005 and is expected to remain near current levels until 2013 after which a gradual rise is expected due to increasing oil production from Canada and the Middle East.

Regional crude oil trade patterns will continue to evolve as long-term production trends continue. Pipeline capacity to supply growing markets in Asia is increasing. Higher production from Africa and South America will also help satisfy the future demand for crude oil in Asia. Closer to home, the expanding pipeline network in North America will increase supply flexibility for the Canadian oil sands. These trends will have significant impacts on refiners and their need for new conversion capacity.

In addition, rapid development of natural gas reserves is causing condensate and LPG to increase strongly, thereby contributing to petroleum supply. New condensate production is contributing to refined product supply, especially naphtha and distillate.

Alternative fuels. A great deal of discussion has been focused on the development of alternative fuels for use in the transportation sector. The primary alternative fuels currently commercially available are biofuels such as ethanol and biodiesel. However, other important alternative fuels include methanol, compressed natural gas (CNG), LPG, gas to liquids (GTLs), coal to liquids (CTLs), electricity and hydrogen. Significant penetration of alternative fuel vehicles would have very important implications for refiners as transportation fuel demand growth would moderate the need for refining capacity. The rapid drop in gasoline consumption in the US is causing the percentage of ethanol blended to increase with negative effects on the refining industry. In Europe, biofuels mandates are also affecting the industry. CTL developments, mostly in China, are gaining importance as a marginal supply source.

We do not expect that biofuels supply will be able to rise to fully meet mandated levels as feedstock, land and food prices rise. Political and financial pressures will continue to cause some countries to scale back mandate policies as biofuels supply becomes tighter and more expensive relative to other alternatives. Third-generation biofuels such as cellulosic ethanol and oils derived from algae will continue to develop technologically and commercially, but deployment of new production capacity will be slow and only limited contributions to global supply will be seen this decade.
**Refining profitability.** Significant new refinery capacity additions combined with a dramatic fall in demand for refined products has created a significant near-term oversupply. A few weaker refineries will likely shut down but the survivors will have to operate at significantly lower rates until after 2015 unless capacity rationalization corrects the balance. Purvin & Gertz analyzed this topic in a study titled, *Rationalization of Refining Capacity* (August 2009). North America, Europe and Japan are where most of the refinery capacity shutdowns are expected to occur.

High refinery margins over the past few years have encouraged refineries to expand and about 275 refinery projects have been announced. Based on our analysis of these projects, we believe that less than 100 will proceed, representing distillation capacity additions of about 8.4 MMBpd by 2017. More importantly, about 7.3 MMBpd of conversion capacity (FCC equivalents) will also start up over the same period. As these new suppliers compete for market share, refinery margins are projected to remain below mid-cycle levels and well below the high levels of the 2004 to 2007 period.

Worldwide refinery investments to 2015 are expected to cost approximately $250 billion, which represents about 15% of 2008 replacement costs. Additional investments in the range of $80 billion are expected through 2025. The increase in carbon dioxide emissions from these projects is estimated to be 230 million metric tpy assuming no carbon capture and storage.

**Purvin & Gertz, International Energy Consultants**

Founded in 1947, Purvin & Gertz is an independent consulting firm providing technical, commercial and strategic advisory services to a broad range of clients in the energy industry. Headquartered in Houston, Texas, the firm maintains an international network of offices in the US, Canada, Europe, Russia, Asia and the Middle East. Purvin & Gertz specializes in serving entities involved in the production, processing, transportation, and marketing of crude oil, natural gas and gas liquids, as well as petroleum products by offering a range of custom consulting services to assist clients in their decision making processes.

Additionally, Purvin & Gertz offers a variety of international energy market studies that analyze market trends and provide forecasts of supply, demand, pricing and production economics of key energy commodities in the most relevant markets around the world.

Our flagship service, the *Global Petroleum Market Outlook* (GPMO), presents an in-depth analysis of long-term trends and developments in the crude oil and refined products markets; it contains a comprehensive examination of the refining industry and an outlook for prices and refining margins in the major refining centers of the world through 2030. The *Crude Oil and Oil Sands Market Outlook* provides an in-depth analysis of North American supply and demand for crude oil, refinery capacity requirements, and an annual special topic related to the oil sands. Both of these services are updated annually with quarterly updates of price and margin forecasts. One of our most recent specialized studies is the *Residual Fuel Market Outlook*, a timely and comprehensive review focusing on the issues of balances and economics of bunker fuel, stationary fuel oil and residual refinery feedstocks.

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Driving optimization and profitability through technology innovation

How hydroprocessing technology enhancements will help you meet your goals

The refining industry continues to face a difficult and dynamic landscape in its efforts toward optimization and profitability. The challenges include feedstock availability and quality, resource limitations, capital spending constraints, environmental regulations, engine requirements, and energy security. While the demand for transportation fuels is increasing, refiners are challenged to meet tighter fuel specifications while processing more difficult feedstocks. In this evolving environment, refiners must not only keep up with changing market demand patterns, but must also drive down costs, grow margins and improve product properties to enhance profitability.

Hydroprocessing technology is a key component in efforts to reach optimal solutions enabling refiners to use more challenging feedstocks and still produce desirable quantities of fuels. These solutions must include improving the quality of liquid transportation fuels to meet pool targets and achieving the maximum value product slate. Utilizing state of the art research facilities in combination with a large commercial experience base, UOP continues to develop hydroprocessing catalyst and process innovations that will allow refiners around the world to meet future challenges.

Multiple configurations for improved product quality and yield

The UOP Unicracking™ process is notable in its ability to handle a wide range of feedstocks and is a core process for increasing the hydrogen content of refinery products for improved product quality and volume swell. Several different process flow schemes are offered to meet individual refinery needs and processing objectives. There are two basic design categories—single-stage or two-stage configurations.

The single-stage Unicracking configuration can be designed for partial feedstock conversion by hydrocracking the feedstock on a “once-through” basis. The once-through single-stage Unicracking process produces high-quality hydrocracked products as well as deeply hydrogenated unconverted oil that makes excellent feedstock to FCC or ethylene cracking units. Alternatively, the unconverted oil product can be readily upgraded to a high-quality lube base stock. In projects where higher conversion is required, the single-stage recycle flow scheme, in which unconverted reactor effluent is recycled, offers a simple cost-effective design for moderate capacity hydrocracking units.

Two-stage Unicracking process configurations offer several advantages in processing heavier, more contaminated feedstocks. In addition, a two-stage Unicracking process design is typically more economical for high throughput applications. In the two-stage configuration, the first stage provides partial feedstock conversion in addition to hydrotreating. Following fractionation to remove products, the second stage provides the remaining conversion of recycle oil so that overall high conversion is achieved. The second stage operates in a low ammonia, low hydrogen sulfide environment.

Recent advances in the Unicracking process and catalyst technologies have focused on increasing operating flexibility of hydrocracking complexes by more efficient use of hydrogen and by increasing feed throughput while, at the same time, improving yields and properties of desired products. The combination of state-of-the-art Unicracking catalysts and innovative process developments ensures that refiners can balance their fuels product slate in efficient and cost-effective ways. The Unicracking process covers the entire spectrum from full conversion to mild hydrocracking with novel flow schemes that offer refiners the option to reduce capital or achieve ultimate flexibility.

With refiners’ interest in converting high-nitrogen, heavy feedstocks to distillate, UOP revisited the two-stage Unicracking technology for optimized distillate production. The result of this optimization is an enhanced two-stage process, which incorporates process and catalyst innovations delivering an increase of 2 to 3 wt% in distillate yield versus the next best alternative while processing high-nitrogen, heavy feedstocks.

In addition to the enhanced two-stage Unicracking technology, UOP has introduced several other hydroprocessing developments in recent years to further assist refiners’ profitability.

Achieve high yields in cost-effective, low-pressure operation

The UOP HyCycle™ Unicracking process is based on UOP’s extensive understanding of the interactions between the catalyst functions and the reaction environment. The process flow scheme incorporates engineering innovations such as the Enhanced Hot Separator (EHS) to permit low conversion per pass, resulting in an economical and energy efficient design. This novel flow scheme results in an improved reaction environment for hydrocracking reactions. The configuration also includes a post treating stage that decouples the cracking and...
hydrogenation reaction stages to allow the hydrocracked product to be hydrogenated in an optimized environment and enables a co-processing option for other distillate streams.

**Optimize diesel and gasoline production across your conversion units**

The UOP Advanced Partial Conversion Unicracking (APCU) process can help refiners with existing FCC units to balance their diesel/gasoline production in a cost-effective manner. This process allows production of ultra-low-sulfur diesel (ULSD) at low conversion in a lower pressure design while pretreating FCC feedstock. The design concept allows the refiner to optimize hydrogen addition to FCC feed while maintaining the proper level of hydrogenation for high-quality distillate. This innovation is important because the unit pressure is often set by the need to produce low-aromatic, high-cetane diesel, and produces unconverted oil with a higher than optimal hydrogen content in the FCC feed, which can result in higher overall hydrogen consumption. The APCU process can reduce hydrogen consumption by 5% to 10% compared to a conventional mild hydrocracking unit. Integration of a separate hydrotreating reactor in the process enables post-treating of other refinery middle distillate streams in a single unit.

Integrating your hydrotreating unit with other upgrading technologies can reduce equipment count and utility requirements for compression, pumping, and process heating. In one case with a Mediterranean refiner, UOP, working closely with the customer, applied an innovative integrated scheme to optimize a residue conversion complex. The site already included a delayed coker, distillate hydrotreater, and a coker naphtha hydrotreater. The solution for optimization was an innovative integration of Distillate Unionfining and Unicracking units, which is projected to deliver greater than $20 million in additional product revenue. For this case, a low-pressure coker naphtha hydrotreater/distillate hydrotreater reactor section and high-pressure hydrocracker reactor section were provided with integrated fractionation and compression. Overall distillate yields should increase by six percent.

**Hydrotreating solutions to meet environmental specs**

Hydrotreating technology is designed to remove contaminants like sulfur, nitrogen, condensed-ring aromatics, and metals. The feedstocks processed range from naphtha to vacuum resid, and the products in most applications are used as environmentally acceptable clean fuels. UOP has offered hydrotreating technology since the early 1950s, and in 1995 UOP joined forces with Unocal to create the Unionfining technology, a high-performance hydrotreating option. In
more recent years, an alliance with Albemarle, the Hydroprocessing Alliance, has expanded the capabilities to provide optimal solutions using complimentary strengths from both companies.

Recent regulatory requirements to produce ULSD and low-sulfur gasoline have created a very dynamic market as refiners must build new units or revamp existing assets to produce “green” fuels. To meet this challenge, UOP’s Clean Fuel Technology Center was created and staffed with experts from several engineering disciplines, working together with customers to address the refiners’ specific configurations and provide optimized and economically attractive solutions. In recent years, demand for low-sulfur gasoline and ULSD has driven the advance of these technologies to meet low contaminant specifications.

UOP offers a number of ways to meet these specifications, from simple catalyst replacement with the new generation of high-activity catalysts to the revamp of existing units. These revamps can include the addition of reactors, makeup hydrogen purification systems, recycle gas scrubbers, improved separation systems, or innovative integration schemes that will maximize product yields and quality in a cost-efficient manner.

**Low-sulfur gasoline production**

Because of feedstock and product requirements that refiners are facing, it is no longer sufficient to develop technology based on manipulation of bulk properties. Technology development has reached a level of sophistication that requires understanding the specific reaction chemistry and how to control it. One example of this sort of technology development is embodied in the UOP SelectFining™ Process. This process uses selective hydrodesulfurization of FCC naphtha to meet low-sulfur gasoline specifications while maximizing octane retention. In order to remove sulfur while retaining the chemical components that are necessary for octane quality, careful design of the catalyst properties and processing conditions is critical.

UOP can offer an optimized FCC and gasoline treating complex along with the SelectFining process and the SelectFining S-250 catalyst to enable minimal octane loss while meeting stringent gasoline sulfur targets. This same S-250 catalyst is a competitive drop-in solution for existing selective hydrodesulfurization units.

The continuous emphasis that UOP has placed on the hydroprocessing process and catalyst innovation, and the full suite of applications that are offered, has resulted in licenses for over 195 hydrocracking units and over 500 hydrotreating units worldwide during the almost 60-year history of these technologies. ■
Cutting-Edge Catalysts

The current economic climate presents a complex set of challenges to refiners. To be effective in providing solutions, catalyst developers must be prepared to streamline their methodology to arrive at optimal solutions in a shorter time period. The successful catalyst provider must be on the cutting edge of new materials development, characterization, application and scale-up. The technological challenge for a catalyst provider is to minimize costs and maximize returns for our clients. UOP has developed a catalyst portfolio that includes a broad range of catalysts designed with specific objectives to improve refinery profitability.

Due to demands for products with more specific requirements, refining technologies, like hydrocracking, are steadily moving from a characterization of feeds and products based solely on their bulk physical properties like distillation, gravity, sulfur and nitrogen content to molecular-level definitions based on classes of individual compounds. As a result of significant scientific and technical advances, we have the capabilities to enhance our understanding, and increase the precision of controlling conversion reaction chemistry. Hydrocarbon types can be varied in their proportions depending on product objectives. To achieve outstanding yields and product properties from processing difficult feedstocks, features like selectivity, activity, stability, and hydrogenation activity are manipulated by intelligent adjustment of the fundamental properties of the catalysts. The strength and distribution of the acid sites in hydrocracking catalysts must be controlled to provide the capability to achieve activity and selectivity targets. In balance with this acid function, the metal function must be optimized to ensure product quality and activity are maintained over the entire cycle. In addition to providing optimized acid and metal functions, the porosity of the catalyst structures must be carefully manipulated to allow optimal access and egress for feed and product molecules. This porosity control becomes particularly important when processing heavy feeds and producing maximum yields of distillate products. In the past, this type of adjustment required a time-consuming set of iterations through multiple formulation and testing steps, which could take years to arrive at improved performance. In recent years, driven by refiner needs for faster development, UOP has constructed a tool set, the Catalyst Design Engine, based on relationships drawn from years of experience in hydrocracking. This tool allows for a first-iteration catalyst formulation, which comes quite close to meeting performance goals and greatly shortens the overall development time for successful catalysts.

Catalyst design engine response surface

Traditionally, catalyst development has tended to focus on the relationship between activity and selectivity, with improved generations of catalysts providing higher activity and selectivity, as shown in Fig. 1. With the current level of sophistication, it is no longer adequate to think in this two-dimensional manner. Our current development strategy is a multi-dimensional approach where catalysts are targeted not just for activity and selectivity goals, but also for the appropriate levels of hydrogenation and product speciation. This allows a selective use of hydrogen resources and avoids adding an excessive amount of hydrogen into boiling ranges where it does not add value.

In UOP’s newest generation of hydrocracking catalysts, varying levels of hydrogenation capability can be found throughout the activity-selectivity range. Fig. 2 shows a two-dimensional representation of catalysts with a broad range of activity and selectivity. The two colors represent different catalyst design strategies with respect to hydrogenation. The catalysts shown in red are designed for selective hydrogen...
addition and improved cold flow properties, while the cata-
lysts shown in blue are designed for maximum hydrogenation
of products and high quality unconverted oil. As new zeolite
structures and improved metal functionalities are developed,
the performance and value of UOP Unicracking catalysts to
refiners will continue to increase.

In order to properly optimize today’s hydrocracking units,
careful attention must be paid to providing the appropriate
catalyst and reaction environment for the molecules present at
all points within the reaction system. The availability of a cata-
lyst portfolio with a broad scope in capabilities allows strategic
placement of optimum catalysts so that maximum yields of
desirable products can be achieved. In the high ammonia, high
hydrogen sulfide first-stage environment, multiple catalysts can
be stacked to minimize over-cracking and reduce quench gas
requirements. Catalysts with acid-metal balances adjusted for
low ammonia environments can be used in the second stage for
maximum high-quality distillate yields. These and other innova-
tive applications of new-generation catalysts will be invaluable
in meeting the needs of refiners as they face future challenges.

While UOP’s new catalysts are being developed with an
increased level of sophistication, the proof of their value comes
with demonstrated performance.

Increase diesel with improved cold flow properties

Unicracking HC-215LT catalyst represents the highest die-
sel selectivity in the catalysts designed for optimum hydrogen
addition and improved cold flow properties. A recent applica-
tion of this catalyst was in a 90% conversion, once-through
Unicracking unit, which had previously used the UOP Uni-
cracking DHC-8 catalyst. The decision to use HC-215LT was
based on the successful performance of this catalyst in another
of their refineries. The unit performance data following the
catalyst change shows an activity improvement of 10°C relative
to the previous cycle with DHC-8. Fig. 3 highlights the HC-
215LT liquid volume yield advantages compared to DHC-8.

This refiner is enjoying both an increase in distillate yield
and an increase in total product volume with the HC-215LT
catalyst. The increase in middle distillate yield was significant
even with a more stringent back end diesel cut point (decreased
from 370 to 350°C).

Capture naphtha and diesel production flexibility

Unicracking HC-185LT catalyst is part of the high-activity
high-selectivity catalyst family, developed to promote asym-
metric cracking and isomerization of paraffins at the expense
of aromatic saturation. HC-185LT features include:
• Maximum flexibility to switch between naphtha and diesel
production within a single catalyst cycle as market conditions
warrant.
• Higher diesel yield than catalysts developed for maximum
naphtha production at a nominal conversion of 30–50 vol% to
diesel and lighter products.
• Lower hydrogen consumption, 10–20%, compared to
analogous catalysts, while improving cold flow properties in
the distillate range material, as shown in Table 1.

As of 2Q 2010, HC-185LT catalyst is operating in four North
American hydrocracking units and is demonstrating the excel-
lent cold flow properties expected for this catalyst. Commercial
data, as shown in Fig. 4, demonstrates the cloud point response
diesel with an initial cut point of 340°F with changes to the
end points, indicating the ability to make arctic diesel with an
end point of 740°F.

Shift to higher diesel production

The Unicracking HC-150LT catalyst is a flexible catalyst
that is ideally suited for providing a shift from naphtha to
higher diesel production. Compared to Unicracking HC-43LT
catalyst, HC-150LT is 10°F more active, consumes 10–15%
lower hydrogen with similar product selectivity.

An early application of HC-150LT was in a European refinery
to meet an increasing diesel market demand by shifting their

TABLE 1. Full-Range Distillate Analysis

<table>
<thead>
<tr>
<th></th>
<th>HC-24L</th>
<th>HC-185LT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud Point, °F</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>Pour Point, °F</td>
<td>16</td>
<td>-11</td>
</tr>
<tr>
<td>CFPP, °F</td>
<td>19</td>
<td>5</td>
</tr>
</tbody>
</table>

Fig. 3. Cycle average volumetric product yields for Unicracking
catalysts.

Fig. 4. Diesel cloud point vs. final boiling range for Unicracking
HC-185LT catalyst.
diesel to gasoline ratio. Changing to HC-150LT and a new-generation pretreating catalyst enabled a significant improvement in the diesel yield. This combination of new catalysts enabled the refiner to process tougher feed and increase the feed rate by 5,000 BPSD while maintaining cycle length. The increased selectivity alone generates $6 million of product value over the cycle without valuing the greater feedrate and flexibility attained. The performance in this unit is summarized in Table 2.

**Increased distillate yield with a new second-stage catalyst**

HC-205LT is a Unicracking catalyst specifically optimized for producing very high distillate yields in a second-stage environment. Relative to the next best alternative catalyst in the second-stage application, HC-205LT has been shown to increase total distillate yield by 2–3 wt% and diesel yield by 3–5 wt%. In addition, HC-205LT has facilitated producing high-quality products while processing heavy, difficult feedstocks. A recent customer study has shown that these improvements for a 50,000 BPSD two-stage Unicracking unit, should result in a $3.8 million increase in annual revenue.

**Maximizing catalyst utilization**

Obtaining full advantage of the most advanced hydrotreating catalysts requires that reactant streams efficiently mix and contact all of the available catalyst inside a fixed-bed reactor. High-performance reactor internals are critical for ensuring good distribution over a range of operating conditions and from the start to finish of a catalyst cycle. In 2006, Albemarle and UOP created the Hydroprocessing Alliance offering hydrotreating technology featuring catalyst and process improvements, including reactor internals based on the complimentary strengths of both Albemarle and UOP.

The D-Plex™ vapor/liquid distribution tray offered through UOP is the latest improvement in this technology, and is a key technology enabler for flexible hydrocracker and hydrotreater operation. These Hydroprocessing Alliance reactor internals ensure optimum performance across a wide range of operating conditions and vapor to liquid regimes, and are applicable to unit revamps or the retrofit of existing internals. All elements of the alliance internals have commercial experience helping refiners achieve maximum benefit by utilizing the full catalyst volume and enabling maximum allowable operating severity. Another very important aspect of the Hydroprocessing Alliance reactor internals design is the ease of installation and maintenance.

The advanced design of the hydrogen processing internals ensures improved liquid distribution uniformity is maintained at liquid flow rates as low as 40 percent of design. In addition, the pressure drop across the internals is low enough to accommodate extra vapor flow up to the process hydraulic constraints. The quench inlet distribution system has been significantly improved, resulting in effective and uniform gas and liquid mixing, as seen in Fig. 5.

The trays are custom designed for each application to ensure maximum performance. This is done to ensure that proper functioning/distribution is occurring across the trays in the various modes of operation being considered. This proper distribution is important to minimize the radial temperature spread of effluents on top of the catalyst bed, and maintain even distribution of liquid and vapor throughout an operating cycle. Poorly-designed reactor internals could allow channeling, mal-distribution, and “by-passing”, a phenomenon in which a certain portion of the feedstock passes through a unit without significant reaction. If allowed to occur, such a poor design effectively leads to a higher space velocity, requiring higher reactor bed temperatures for the same conversion or product specification. The subsequent outcomes include loss of catalyst life, poor product quality, and unscheduled unit shutdowns.

UOP provides on-site support and supervision for reactor internals installation. Over 440 Albemarle and UOP distribution trays have been installed and operated worldwide since 1991.

**TABLE 2. European Refiner Operating Conditions, HC-24L Change to HC-150LT**

<table>
<thead>
<tr>
<th></th>
<th>Original Design</th>
<th>After Catalyst Change-out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedrate, BPSD</td>
<td>30,000</td>
<td>35,000</td>
</tr>
<tr>
<td>Feed</td>
<td>HVGO, visbreaker</td>
<td>HVGO, visbreaker HVGO, lube extracts</td>
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<td>HPS Pressure, psig</td>
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<tr>
<td>Catalyst: Pre-treat</td>
<td>Type I</td>
<td>Type II (KF 848)</td>
</tr>
<tr>
<td>Hydrocracking</td>
<td>HC-24L</td>
<td>HC-150LT</td>
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<tr>
<td>Conversion, wt%</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Distillate yields, wt%</td>
<td>33</td>
<td>40</td>
</tr>
</tbody>
</table>

![Fig. 5. Pressure gradient over the vapor/liquid distribution tray.](image)
Aligned to offer you more

UOP and Albemarle are working together for fully integrated hydproprocessing solutions

In 2006, Albemarle and UOP created the Hydroprocessing Alliance to deliver integrated refinery solutions and innovative hydproprocessing technologies and catalysts to the refining industry. Today, the alliance provides economic benefits and greater flexibility to customers with the most comprehensive portfolio of processes, catalysts, equipment and services available.

Traditionally, refiners have managed the complex task of combining the capabilities of various suppliers to achieve the improved output and efficiency they need. The Hydroprocessing Alliance eliminates much of this effort, combining the resources and expertise of two industry leaders.

The alliance provides the latest hydrocracking pretreat and cracking catalysts as well as an enhanced integration of the two for both new and existing units. This combination allows refiners to experience longer cycle lengths, greater operational robustness, a wider choice for selectivity to desired products and lower operational and capital costs.

The alliance makes an incredible breadth of solutions available to refiners. This includes the recently introduced Albemarle Ketjenfine (KF) 860 STARS™ and KF 868 STARS catalysts. KF 860 was developed to minimize the effect of worsening feed quality. The product reduces the impact of deactivation from coking and metals contamination. Its uniform pore-size distribution and large pore diameter has improved robustness in several commercial applications. KF 868 exhibits similar stability characteristics with considerably higher activity, and is designed to improve vacuum gas oil hydrocracking operations for processing lower-quality feedstocks, increasing unit throughput, or allowing the use of more selective hydrocracking catalysts.

Through the alliance, refiners also have access to Albemarle’s state-of-the-art NEBULA® hydrotreating catalyst, an innovative material discovered by ExxonMobil Research and Engineering Company and co-developed with Albemarle. The exceptionally high hydrogenation (HDN) and hydrodearomatization (HDA) activities from NEBULA reduce bottlenecks in hydrotreaters limited by hydrotreating catalyst performance. It has been used in over 40 applications, including hydrocracker pretreat, since its introduction in 2001.

For distillate hydrotreating, the alliance makes available the Albemarle’s KF 770 and KF 771 catalysts, to meet ULSD specifications across a wide range of operating conditions and feed qualities.

UOP and Albemarle design hydrotreating units using the Albemarle STAX™ methodology to design catalyst systems optimizing certain reactions taking place within a hydrotreater. This technology allows refiners to “see” inside the reactor and develop a simulation model that predicts performance at any point in the catalyst bed. Each ULSD unit is unique, and the best economic return comes from applying a catalyst system that is tailored to its specific operating conditions and feed properties.

When these solutions are combined with the strength of the UOP hydproprocessing catalyst and technology portfolio, refiners will find the solution that meets their specific operational goals. Catalyst customization completed during the design phase using UOP engineering capabilities results in a unit optimized for utility consumption or erected cost. Customer risk is minimized when applying the catalyst system and unit design that will continually produce on-spec products.

In addition to its leading position in hydrotreating to produce ULSD and hydcracking technologies, the Hydroprocessing Alliance has successfully developed catalyst and process offerings for coker naphtha hydrotreating, VGO hydrotreating and resid hydrotreating. In the hydrotreating market alone, UOP has licensed more than 60 Unionfining units using the step-out performance of Albemarle’s catalysts. The alliance has also accelerated innovations in process design and catalysts resulting in shorter time-to-market supply of technology. Thus allowing refiners to meet complex project demands with lower capital cost and greater operational robustness at a faster pace.

The Hydroprocessing Alliance is a unique collaboration of resources from UOP, A Honeywell Company and Albemarle.
The demand for high quality diesel is projected to grow more rapidly than other transportation fuels in the majority of the world’s regional markets over the next ten years.

Even though this demand growth projection is well supported, refiner’s choices on how to deal with this “dieselization” trend are not straightforward. Near-term gasoline and diesel demand trends are likely to be volatile. Other complicating factors include cost and availability of feedstocks, uncertain diesel-gasoline product value differentials, seasonal changes in product demand, and environmental regulations. One critical capability for dealing with this complex matrix of issues is flexibility for optimal production of quality gasoline and diesel products. This ability allows a refiner to maximize profitability by responding intelligently to changes in market conditions.

The need for short term flexibility and meeting long term diesel demand is driving towards more hydrcracking capacity to increase production of high quality diesel. Recent advances in the Unicracking process and catalyst technologies have focused on increasing operating flexibility of hydrcracking complexes. This is accomplished by a more efficient use of hydrogen and the ability to process additional feed while improving yields and properties of desired products. The combination of state-of-the-art catalysts and innovative hydrcracking process developments ensures that refiners can balance their diesel–gasoline production in the most efficient and cost-effective ways.

Technology developments for improved distillate yields and quality

In response to the increasing need for high-capacity, maximum distillate hydrcracking units, UOP initiated a technology renewal program to advance both the process and catalyst technology for its two-stage Unicracking process. Advancements in the design of this technology include innovations in each reaction section.

Optimal design of the catalyst system for two-stage hydrcracking requires a thorough understanding of the reaction chemistry in each stage. In a two-stage Unicracking process configuration, the first-stage reaction environment is rich in both ammonia and hydrogen sulfide generated by hydronitrogenation and hydrodesulfurization of the feed. The pretreating section uses a high activity catalyst enabling high severity feed hydrotreating, delivering a better quality feed to the first-stage hydrcracking section. The first-stage hydrcracking catalyst, in series flow with the pretreating catalyst, receives a hydrotreated feed largely free of organic nitrogen and sulfur. This feed is rich in paraffins, isoparaffins, naphthenes, and naphthene-aromatic compounds. The predominant reactions are aromatic hydrogenation, ring opening, and de-alkylation in addition to isomerization and cracking of paraffins. The hydrocarbon stream that exits the first-stage hydrcracking reactor is rich in medium to short chain paraffins, naphthenes, and alkyl aromatics with short to moderate length side chains. This maximizes first-stage selectivity to high quality distillate.

After fractionating the first-stage effluent, very low concentrations of ammonia and hydrogen sulfide pass through to the second-stage reactor. This change in environment significantly impacts reaction rates, particularly cracking reaction rates, leading to very different catalyst behavior in each stage. This results in independently designed catalyst systems for the two reaction stages, which enables optimum conversion severity in each stage and maximizes the overall distillate selectivity.

Conditions in the second-stage are more favorable to conversion of the refractory components in recycle oils due to the relatively clean nature of this oil and near absence of ammonia and hydrogen sulfide in the recycle gas. The second-stage hydrcracking catalyst is designed to take advantage of the cleaner reaction environment by tuning the balance between the acid and metal functions of the catalyst specifically to the reaction environment in that stage. Reaction severity is optimized to maximize distillate selectivity from the hydrcracking reactions. In addition to improving the ability to optimize conversion severity in the two stages, UOP developed a new second-stage catalyst that achieves significantly higher distillate selectivity than former generations of hydrcracking catalysts.

Incorporating these process and catalyst innovations resulted in the Enhanced Two-Stage Unicracking process. This process delivers an increase

Fig. 1. Global demand for refined products. Source: Purvin & Gertz
of 2–3 wt% in distillate yield over the next best alternative in the market. The increase in distillate yield also includes a shift in selectivity to produce 3–5 wt% more high-quality diesel product. The yield increase has been demonstrated on a wide range of feedstocks, including difficult high-nitrogen and high endpoint materials. The product qualities from the enhanced two-stage operation are excellent, producing low aromatics, high cetane with ultra low levels of sulfur in the diesel product as seen in Fig. 1.

Data collected through customer studies allows UOP to confidently adjust the optimum conversion and catalyst configuration for changes in feed quality and specific operating constraints. In addition to yield and quality advantages, this two-stage configuration gives the refiner tremendous flexibility for adjusting to seasonal or market changes.

**Increasing flexibility and maximizing profits for existing operations**

Although long-term demand for high quality diesel is predicted, the demand path will not necessarily be straightforward, and will contain periods of significant swings between naphtha and diesel demand and profitability. As a result, refiners would like the capability to shift hydrocracker operations to flexibly produce either naphtha or diesel. They need cost-effective solutions to successfully increase diesel yields from existing refinery assets but with flexibility for maximum production of diesel or naphtha as their local market dictates.

UOP, with over 100 refinery catalysts and over 70 process technologies installed worldwide over a period of almost 100 years, is uniquely suited to evaluate production potential from existing units. In response to refiner needs, UOP has assembled commercial operating and existing pilot plant data maps to compare against the existing naphtha hydrocracker landscape and identified specific data needs to be addressed. An exhaustive hydrocracking capability project was developed to provide solutions addressing issues concerning catalyst selection, operating conditions, equipment constraints, and economic viability. In addition to considering the refiner needs, existing data, and unit landscape, this project included a pilot plant program to fill data gaps and project specific customer studies.

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![Figure 2](image_url) **Fig. 2.** Product quality for diesel produced using the Enhanced Two-Stage Unicracking Process.
Customer studies

From the existing naphtha hydrocracker landscape UOP chose three units to evaluate via additional pilot plant testing and customer studies. These units were among the customer inquiries received by UOP to increase diesel production from existing naphtha hydrocracker assets.

The basic approach for each Customer Study was to:

• Evaluate target diesel flexibility range
• Optimize catalyst selection and operating conditions
• Determine revamp and capital cost requirements
• Perform economic evaluation with sensitivity analysis to key drivers
• Summarize key learnings with respect to catalyst selection, common equipment bottlenecks, and key economic drivers

These customer studies covered a broad range of unit configurations enabling the development of pre-positioned solutions that are applicable to the overall market landscape. Translating the knowledge gained from this project into tools that can successfully address customer inquiries was the final critical step.

The key outputs of the project have expanded capabilities in three key areas:

Performance Estimating. UOP has established an expanded pilot plant database that will enable quick execution on performance estimates with optimized matching of catalyst features to customer needs.

Revamp Engineering. Pre-positioned revamp engineering solutions cover the market landscape and identify typical revamp investment costs.

Economic Evaluation. This project yielded an economic screening tool that allows cost benefit analysis of potential catalytic and revamp solution options. Evaluating project cost and product objectives requires in-depth knowledge and application of refinery-wide technologies, evaluating both catalyst and process designs, to meet these new challenges.

UOP’s catalyst recommendations with respect to naphtha and diesel production depend primarily on the refiner’s product requirements including max naphtha production, max diesel production, or the ability to flexibly switch between naphtha and diesel production. Hydrocracking catalysts can be simply classified by activity and selectivity to distillate yield. UOP continues to develop its Unicracking catalysts across the entire range of product objectives.

Refiners looking to address market trends must work with partners that can offer a full breadth of catalyst solutions as well as a strong understanding of how to revamp existing assets effectively and cost efficiently. UOP has worked with hundreds of refiners through the last 50 years to develop hydroprocessing revamp projects of all magnitudes. This experience has resulted in the development of a variety of revamp engineering services that are tailored to meet refiners needs. This extensive experience conducting process revamps has been on both UOP process technology units as well as other units. In the past 10 years alone, UOP has issued over 50 revamp Schedule A packages and conducted over 170 process and equipment studies in the hydroprocessing area.

Today’s market has shifted to one with local and seasonal fluctuations in diesel demand and pricing advantage. Naphtha hydrocrackers offer potential for shifting between gasoline and diesel production to capture maximum profit. UOP’s recent investment in hydrocracking unit capability development allows for a rapid response with prepositioned solutions to address this situation. UOP offers refiners a proven partner in the quest for naphtha/diesel flexibility or maximizing diesel production from existing hydrocracker assets.

In addition, UOP is continuously pushing the state-of-the-art in process and catalyst development as evidenced by innovative new configurations including the Enhanced Two-Stage Unicracking technology for maximum distillate yields and flexibility.

### TABLE 1. Summary of the customer studies

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Feed type</th>
<th>Change in diesel production, vol% FF</th>
<th>Uncoverted oil product routing</th>
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<td>2</td>
<td>LVGO, HVGO, DAO</td>
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<td>Diesel product blending</td>
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<tr>
<td>3</td>
<td>LCO, SRGO</td>
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Sponsored Supplement

Short- and Long-Term Diesel Strategy

MAXIMIZE ASSETS. DRIVE RESULTS. | 14
Tüpraş chooses UOP hydroprocessing to boost ULSD yields

Tüpraş will use UOP process technologies and catalysts to improve yields and boost performance at its Izmit Refinery in Turkey. Working closely with Tüpraş personnel, UOP engineers developed an innovative approach integrating three new units projected to deliver greater than $30 million in capital expenditure savings and greater than $20 million per year in yield improvement benefits.

Located in the heart of the largest Turkish consumption region for petroleum products, the Izmit Refinery is one of four refineries owned and operated by Tüpraş, an integrated petroleum company and Turkey’s largest industrial enterprise. Tüpraş has the system-wide capacity to process 28.1 million tons (about 211 million bbl) of crude oil per year. The Izmit Refinery has an 11 million ton (82.5 million bbl) annual capacity. The Izmit Refinery processed 10.3 million tons of crude oil in 2008, achieving 94 percent of capacity and breaking production records for the facility and for several products, including diesel and jet fuel.

Tüpraş management launched a residue upgrade project in 2007 to meet increased customer demand for refined products, especially ultra-low-sulfur diesel (ULSD) and kerosene. The first stage of the project was to evaluate different options for upgrading the residue and to select the most economic option for the Izmit Refinery. Tüpraş has strong internal refinery development and computer modeling skills, and these were used to select the optimum configuration.

With UOP technology already widely used at the refinery, Tüpraş personnel and UOP regional service people had built a strong and positive relationship over the years. Building on this relationship, UOP consultants in refinery configuration and hydroprocessing technologies assisted the Tüpraş project team by providing technical information relating to different upgrading process options.

With the residue upgrade project, the refinery was looking to increase production of high-demand, high-value products, especially ULSD and kerosene. Tüpraş management wanted to use only commercially proven technology and catalysts. They wanted to continue to improve overall refinery productivity while ensuring compliance with new and projected European Union environmental standards. Finally, they wanted a flexible, cost-effective solution that considered both the front-end and total life-cycle price tag for the project.

The UOP hydroprocessing solution is estimated to deliver significant improvement in on-spec distillate yields resulting in greater than $20 million in incremental annual revenue.

The Tüpraş staff developed a recommendation calling for the creation of a new conversion complex with delayed coking, hydrocracking, distillate hydrotreating and coker naphtha hydrotreating capabilities.

Having chosen an optimum configuration for the project, the second stage of the project was to select the process technologies to be used within the complex. Tüpraş organized a very detailed licensor selection for each of the units. This was designed to ensure that the technologies offered by different licensors could be compared directly on the same basis, while still leaving room for optimization of operating conditions, yields and capital cost.

Enhanced two-stage Unicracking for higher yields of on-spec products

UOP recommended that the refinery use an enhanced two-stage hydrocracking process to upgrade vacuum gas oil and heavy coker gas oil to high value kerosene and diesel products that fully meet today's rigorous specifications. The company’s engineers were able to provide a flexible hydrocracking solution tailored for the specific needs of the Izmit Refinery, based on the proven UOP Unicracking technology.

The UOP proposal recognized that creating capacity to produce more kerosene and low-sulfur diesel was the primary value driver for Tüpraş. By tailoring the Unicracking process and catalysts to meet the refinery’s specific objectives, UOP engineers were able to improve yields and increase flexibility by enabling the unit to produce the highest yield of kerosene and diesel from the available feedstock available in the market.

Integrated solution for capital savings

Following an evaluation of different options for processing the coker naphtha and distillate-range feeds, Tüpraş selected co-processing of the coker naphtha with the distillate streams in a single hydrotreating unit that was integrated with the hydrocracking unit. UOP team members created a hydroprocessing solution that met the sulfur specifications and other technical product requirements that Tüpraş established during the project-definition phase at a significantly lower capital cost than building individual processing units.

The integrated coker naphtha/distillate hydrotreating unit is part of the UOP MQD Unifining family of technologies used to produce high-quality diesel fuel that meets the most stringent of requirements, including the low-sulfur and aromatics content required by current and anticipated environmental regulations. The hydroprocessing units will use sophisticated, commercially proven multifunction catalysts that were chosen to meet the product-quality standards that the Tüpraş officials specified.

Following selection of UOP technology for the hydroprocessing units in the
complex, Tüpraş initiated a further optimization step to refine the basis for the final design. Working closely with the Tüpraş project team, UOP optimized the operating conditions and configuration of the integrated unit. This led to a further step increase in the yield of valuable distillate products.

By working closely with the Tüpraş team, UOP specialists were able to apply the company’s broad, cross-discipline expertise in technology, processes and catalysts to create a solution that addressed all of the customer’s priorities and concerns.

By integrating the Unionfining and Unicracking units, the UOP approach will save Tüpraş an estimated $30 million in capital costs and improve net present value by about $50 million, according to a Tüpraş estimate.

The UOP solution is projected to deliver significant improvement in on-spec distillate yields, resulting in more than $20 million in incremental annual revenue for the refinery, compared to other proposed approaches. Further improvements may be possible after the units come online in the 2014 timeframe as even more efficient commercial catalysts become available.
Producing blendable transportation fuels from a wide range of nonconventional feedstocks can be complicated. The push for higher percentages of renewable fuels in the global fuel supply poses significant challenges for most refiners as renewable feed sources change regionally. UOP is committed to the challenge of providing step-out technology in order to meet our customer needs and the tremendous projected growth in energy demand. Recent development programs involving non-edible, second-generation oils such as jatropha, camelina, algae and tallow address the need to produce more renewable fuels. In addition, energy security issues have driven renewed interest in processing used motor oil, shale oil and Fischer-Tropsch (FT) liquids from gasified materials including pet coke, coal and cellulosic wastes.

For all of these feed types, UOP and its partners are licensing technology that will meet Euro-quality diesel and jet fuel specifications for direct blend with conventional refinery products. UOP is focused on leading the charge with processing options that address a diverse array of alternate feed sources. These innovations can reduce carbon footprints, increase availability of renewable components, and improve energy security for nations across the globe.

Converting natural oils and wastes to drop-in biofuels

The production of renewable fuels is continuing to expand worldwide as a result of increasing petroleum prices, government regulations, and commitments to greenhouse gas reduction. To date, there has been little integration of renewable fuels production within petroleum refineries despite the increasing demand for renewable fuels.

Segregated production of renewable fuels outside the existing refinery infrastructure increases cost and can slow adoption. To address this challenge, UOP has developed renewable energy processes that utilize traditional refining technology. The UOP/Eni Ecofining™ process for the production of green diesel and the UOP Renewable Jet process utilize fixed-bed hydroprocessing technologies capable of addressing the chemistry associated with conversion of oils and fats into hydrocarbon alkanes for superior fuel quality. These zero-sulfur, high-cetane number (75–90) and low freeze point products are virtually indistinguishable from petroleum-based fuels and serve as excellent blend stocks. They allow refiners the ability to blend lower-quality distillate into the refinery pool unlike additive products such as FAME (biodiesel).

Several refiners are working on renewable development projects today. The aviation industry has also been an important driver in the testing and certification of fuels. UOP is working closely with several refiners and will also produce up to 600,000 gallons of Honeywell Green Jet Fuel™ for use in US Navy and Military flight testing.

Processing Fischer-Tropsch liquids for high-cetane diesel and no-sulfur jet fuel

The abundance of coal, natural gas and biomass available today is driving interest in the use of FT technology to produce quality transportation fuels. The UOP upgrading technology can produce premium quality, no-sulfur jet and diesel fuels with cetane numbers in the 70’s from the FT liquids.

UOP’s experience in the characterization and testing of FT-derived liquids began several decades ago, when UOP was contracted by the US Department of Energy to provide assistance in the upgrading of FT synthesis products. This work was performed in UOP’s pilot plant facilities in Riverside and Des Plaines, Illinois. Since that time, UOP
has extended its knowledge of FT liquids upgrading through extensive pilot plant testing of FT liquids derived from both cobalt fixed-bed and iron slurry FT processes. These programs have yielded the identification of UOP-proprietary catalyst systems, which can optimize product yields as well as the production of high-quality diesel and jet fuels.

Although process selection may vary depending upon processing objectives and desired product slate, UOP-designed FT liquids upgrading facilities will typically include combinations of the UOP FT Unionfining, Unicracking and the UOP Catalytic Dewaxing process technologies. This technology combination allows:

- Stabilization of the FT liquid’s lighter fraction, by reducing its bromine number and converting its oxygen-containing components, to produce a storable naphtha-range product
- Conversion of the heavier portion of the FT liquid’s lighter fraction to produce jet- or diesel-range blending components
- Stabilization of the FT liquid’s heavier wax fraction by reducing its bromine number and oxygen content
- Conversion of the FT liquid’s heavier wax fraction to produce jet- or diesel-range blending components
- Improvement of the cold flow properties of the FT liquid’s lighter fraction to enable it to be included in the diesel or jet blending pool.

Converting shale oil to transportation fuels

In some regions of the world, shale oil is a significant resource, which can be converted into high-quality liquid fuels with the proper processing solutions. The estimated number of barrels of oil reserves from shale in the US alone is over 2 trillion. Catalytic and process technology for the treatment of shale oil was developed by Unocal to support a commercial operation in Parachute Creek, Colorado. This site operated a 10,000-bpsd shale retorting and upgrading facility from 1983 until 1991.

In 1995, UOP acquired the technology and began development efforts to address the significant challenges related to processing shale oil. Contaminants like shale fines, arsenic, and unusually high contents of olefins, aromatics, nitrogen, and sulfur were the key issues that had to be addressed.

Renewed interest in processing shale oil in the US, China, Jordan and Estonia has driven further improvements to both catalytic and process technologies in order to meet Euro Diesel specifications. Today, UOP is working with clients in the US and Europe where energy security issues are driving further developments. Many of these clients have long histories of producing fuel oil from shale, but they need expertise in order to improve the quality of the material for transportation use. UOP’s proprietary advanced catalyst systems provide the ability to upgrade the various qualities of shale oil into products including high yields of blendable Euro-quality distillate.
refining your profit

UOP helps you exceed your goals with innovative technology, catalysts and optimization solutions specifically designed to meet your needs.

UOP hydroprocessing solutions and optimization services are designed to help you maximize your return on investment and grow your business. As regional market demands shift, we provide the process technologies, catalysts and services that will meet your changing business needs. Our experts work closely with you to meet your desired yields and product specifications including ultra-low sulfur diesel standards while improving your operational efficiency.

Backed by over 50 years of hydroprocessing innovations, UOP offers the best and most advanced solutions to keep your business one step ahead.

A Honeywell Company

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