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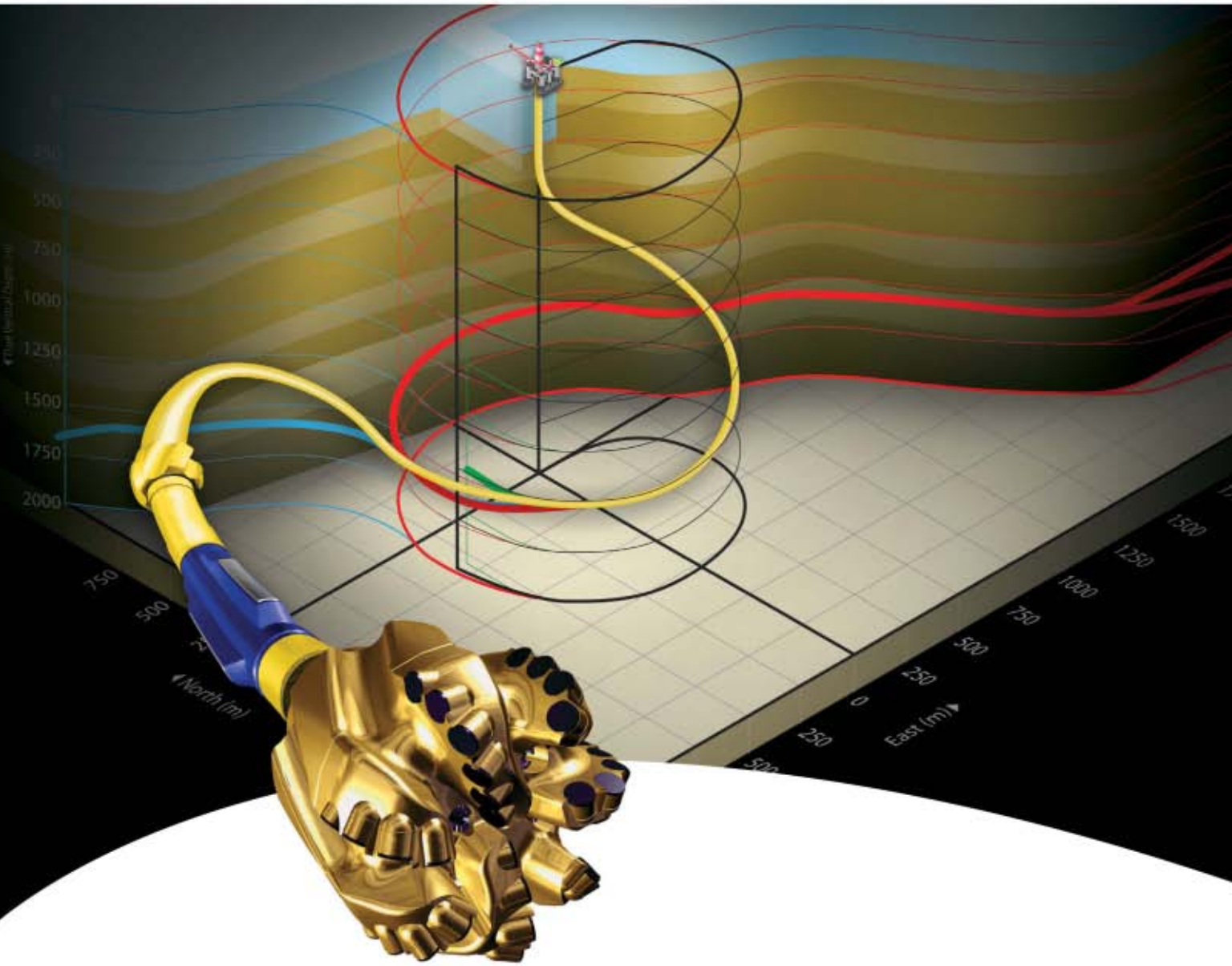

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Oil Field Cost Trends

Outlook for US gas supply improves if production stepped up
Petrobras continues to add producing facilities off Brazil
US olefins see improving feed economics, demand
Tanker earnings continue slide

OIL&GAS JOURNAL®

Feb. 4, 2008
Volume 106.5

OIL FIELD COST TRENDS

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COVER

Apache Corp. has an aggressive drilling program at Stiles Ranch gas field in Wheeler County, Tex., where it reduced costs through drilling technology and greater efficiency. During the last 18 months, Apache reduced the average cost of each Stiles Ranch well by $200,000. This issue's special report, Oil Field Cost Trends, begins on p. 20 with an article including comments from Tom Voytovich, vice-president of Apache's Central Region. In a second article, p. 24, representatives of the Texas Alliance of Energy Producers discuss how independents handle rising costs. Photo from Apache.

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General Interest — Quick Takes

Interior orders mineral reforms after report

US Interior Secretary Dirk A. Kempthorne, after receiving the final report of an independent study panel on Jan. 25, ordered immediate implementation of recommended mineral management reforms that can be carried out administratively.

The report, having more than 100 recommendations, came from a bipartisan panel the secretary formed last year that was co-chaired by former US Sens. Bob Kerrey (D-Neb.) and Jake Garn (R-Utah). "Where it is within our power to do so, the responsible officials will take action to rectify identified problems. However, other recommendations may require further study or legislative action," Kempthorne said.

His directive to Minerals Management Service Director Randall B. Luthi and Bureau of Land Management Director James L. Caswell also orders the two agencies to develop action plans based on the report's recommendations and to submit a progress report within 30 days. The recommendations, to be implemented immediately, include additional ethics training for all MMS employees, especially those who deal with oil, gas, and other lessees in a regulatory, collections, or enforcement role.

MMS also is upgrading its communication and coordination to ensure the accuracy of lease and royalties collections, Interior said. It indicated that the agency also recently issued an Indian Oil Valuation Rule to provide added certainty to the valuation of oil produced from American Indian lands, a key issue that the study panel identified.

Kempthorne said some of the panel's recommendations need further exploration through consultations with state and Indian tribal officials and, in some cases, industry organizations before they can be adequately implemented.

Nigeria, Portugal hold gas development talks

Portugal has joined Russia, China, and India in seeking to cooperate with Nigeria in tapping into that African country's gas potential as it seeks to ramp up domestic gas utilization as a priority and develop export projects.

Following a meeting of Nigeria's Gas Minister Odusina Olatunde Emmanuel and Portugal Ambassador Maria De Fatima Perestrello, Emmanuel said there was sufficient gas in the country to meet both commitments, and gas for power generation is high on its agenda.

Perestrello assured Emmanuel that it was possible to combine gas development with environmental protection. Portugal is seeking a "very close relationship" with Nigeria, a statement from the minister said.

Under a Niger Delta Development Plan, which aims to resolve the problems that have plagued the region and led to outbreaks of violence and unrest, the government is "working hard" to restore peace in the Niger Delta "very soon," Emmanuel said.

Nigeria's zero gas-flaring target, which has been continuously postponed, could be achieved by December, he said, and he was optimistic that all stakeholders would comply with the mandate this time.

Ecuador gives IOCs 'new contract' deadline

Ecuador's President Rafael Correa, advancing a deadline mooted earlier, said Jan. 26 that international oil companies operating in his country—including City Oriente, Petroleo Brasileiro SA (Petrobras), Perenco, Repsol-YPF SA, and Andes Petroleum—would have 45 days to accept new agreements.

The government wants to change the current contracts from joint ventures, which allow IOCs to include Ecuadorean reserves on their balance sheets, to subcontracting deals, which do not.

Oil and Mines Minister Galo Chiriboga, who earlier spoke of a May deadline for the changes, also warned the companies that the new contracts would end their option of appealing to the World Bank's International Centre for Settlement of Investment Disputes.

In 2007 Correa's government unilaterally altered the allocation of the windfall produced by the rise in international oil prices: the government now takes 99% of the windfall and the companies get 1%—a decision the companies are fighting in the courts.

Correa gave the companies three choices: to accept the 99% decree, to accept the new contracts, or to leave the country. If they leave, Correa said, the government will reimburse them for their investment and turn the fields over to state-owned oil company Petroecuador.

Economy Minister Fausto Ortiz recently said the government expects to receive an additional $1.1 billion in oil revenues during 2008, all coming as a result of the new taxation on foreign companies' extra oil revenues.

Ortiz acknowledged that the additional revenue will depend on the renegotiation of contracts with the five oil companies. ✦

Exploration & Development — Quick Takes

Petrobras to spend $12 billion in Santos by 2012

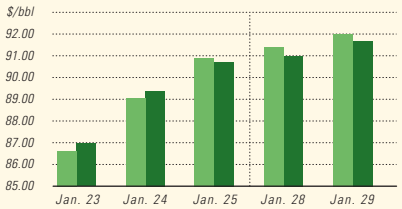
Brazil's Petroleo Brasileiro SA (Petrobras), following earlier remarks about its recent offshore discoveries, said it will invest $12 billion in the Santos basin by 2012.

Production from Mexilhao field alone was expected to reach 15 million cu m/day of gas—a volume equal to about 30% of Brazil's current gas demand, Petrobras said.

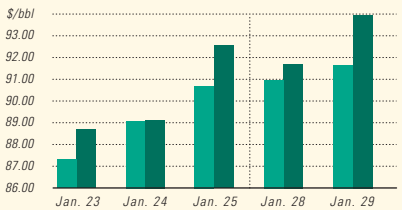
Other Santos basin projects include the development of Uru-

Industry Scoreboard

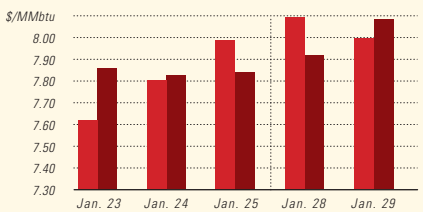
IPE BRENT / NYMEX LIGHT SWEET CRUDE



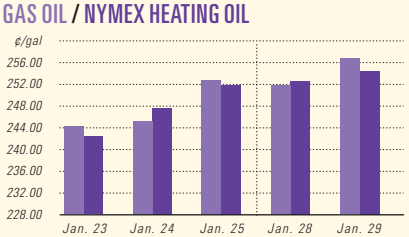
WTI CUSHING / BRENT SPOT



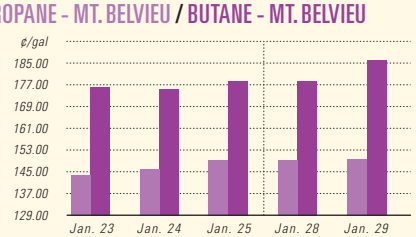
NYMEX NATURAL GAS / SPOT GAS - HENRY HUB



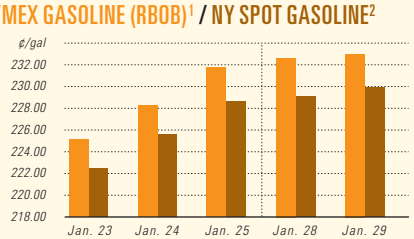
IPE GAS OIL / NYMEX HEATING OIL



PROPANE - MT. BELVIEU / BUTANE - MT. BELVIEU



NYMEX GASOLINE (RBOB)[1] / NY SPOT GASOLINE[2]



[1]Reformulated gasoline blendstock for oxygen blending
[2]Nonoxygenated regular unleaded.

US INDUSTRY SCOREBOARD — 2/4

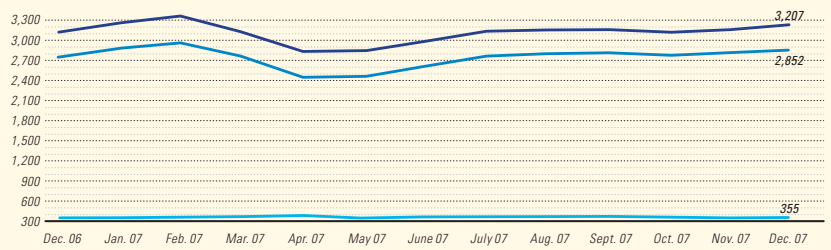
Latest week 1/18	4 wk. average	4 wk. avg. year ago[1]	Change, %	YTD average[1]	YTD avg. year ago[1]	Change, %
Demand, 1,000 b/d						
Motor gasoline	9,168	9,067	1.1	9,128	8,891	2.7
Distillate	4,282	4,268	0.3	4,262	4,267	–0.1
Jet fuel	1,557	1,622	–4.0	1,546	1,616	–4.4
Residual	820	745	10.1	810	753	7.6
Other products	5,137	4,950	3.8	5,090	5,032	1.2
TOTAL DEMAND	20,964	20,652	1.5	20,836	20,559	1.3
Supply, 1,000 b/d						
Crude production	5,046	5,184	–2.7	5,035	5,196	–3.1
NGL production[2]	2,427	2,314	4.9	2,396	2,250	6.5
Crude imports	10,090	9,942	1.5	10,117	10,192	–0.7
Product imports	3,284	3,327	–1.3	3,282	3,431	–4.3
Other supply[3]	1,111	915	21.4	995	1,048	–5.1
TOTAL SUPPLY	21,958	21,682	1.3	21,825	22,117	–1.3
Refining, 1,000 b/d						
Crude runs to stills	15,271	15,553	–1.8	15,234	14,964	1.8
Input to crude stills	15,444	15,606	–1.0	15,397	15,385	0.1
% utilization	88.6	89.6	—	88.3	88.1	—

Latest week 1/18	Latest week	Previous week[1]	Change	Same week year ago[1]	Change	Change, %
Stocks, 1,000 bbl						
Crude oil	289,397	287,100	2,297	322,243	–32,846	–10.2
Motor gasoline	220,341	215,256	5,085	220,795	–454	–0.2
Distillate	128,543	129,845	–1,302	142,625	–14,082	–9.9
Jet fuel-kerosine	39,752	40,052	–300	40,203	–451	–1.1
Residual	38,540	37,902	638	45,611	–7,071	–15.5
Stock cover (days)[4]			Change, %		Change, %	
Crude	19.0	18.7	1.6	21.1	–10.0	
Motor gasoline	24.0	23.2	3.4	24.2	–0.8	
Distillate	30.0	29.8	0.7	35.2	–14.8	
Propane	26.8	29.9	–10.4	33.0	–18.8	

Futures prices[5] 1/25			Change		Change	%
Light sweet crude, $/bbl	89.24	91.53	–2.29	51.48	37.76	73.3
Natural gas, $/MMbtu	7.77	8.15	–0.38	6.52	1.25	19.1

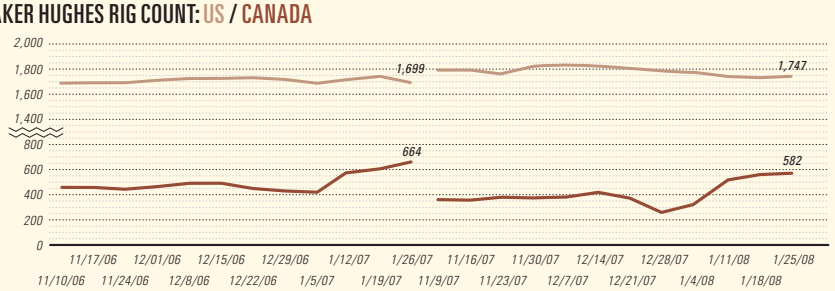
[1]Based on revised figures. [2]Includes adjustments for fuel ethanol and motor gasoline blending components. [3]Includes other hydrocarbons and alcohol, refinery processing gain, and unaccounted for crude oil. [4]Stocks divided by average daily product supplied for the prior 4 weeks. [5]Weekly average of daily closing futures prices.
Sources: Energy Information Administration, Wall Street Journal

BAKER HUGHES INTERNATIONAL RIG COUNT: TOTAL WORLD / TOTAL ONSHORE / TOTAL OFFSHORE



Note: Monthly average count

BAKER HUGHES RIG COUNT: US / CANADA



Note: End of week average count

gua, Tambau, Caravela, and Cavalo Marinho fields as well as the construction of a gas treatment unit in Caraguatatuba. Petrobras said it was expecting production of 30 million cu m/day of gas and 100,000 b/d of oil.

Petrobras's recent discovery of Jupiter gas-condensate field in the basin reinforces the notion that there is practically no exploratory risk in the presalt layer, a Petrobras executive said.

The first Jupiter well, 1-BRSA-559-RJS (1-RJS-652), was drilled to 5,252 m in 2,187 m of water about 290 km off Rio de Janeiro state, just 37 km from the Tupi area.

Repsol-YPF makes gas find in Peru near Camisea

Repsol-YPF SA made a gas discovery with its Kinteroni X1 exploration well, drilled on Block 57 in Peru near the Camisea project.

Initial production tests registered gas flows of 1 million cu m/day and 198 cu m/day of associated liquids. The field's reserves are estimated at 2 tcf of gas.

Repsol-YPF is operator with a 41% stake.

Domestic demand for gas is estimated to total 6 tcf in the next 20 years, according to Energy and Mines Minister Juan Valdivia.

Peru's proved gas reserves total 16 tcf, including the reserves in Blocks 88 and 56 of the Camisea project, the recently discovered gas by Repsol-YPF on Block 57, and the discoveries of BPZ Energy Inc. and Peruvian oil company Petro-Tech Peruana in northern Peru.

Valdivia said the government will invest $35-37 million in 2008 to expand the country's gas distribution networks. He said the government will invest part of the sum to replace old copper pipes with ones made of aluminum.

Apache makes finds in Egypt, Australia

Houston independent Apache Corp. reported the first two hydrocarbon discoveries of its 2008 exploration program, in Australia and Egypt.

On test, the Hydra-1X exploration well in Egypt's Western Desert flowed 41.6 MMcfd of natural gas and 1,313 b/d of condensate from the Jurassic Lower Safa formation. The well, which is in a sparsely drilled area in the Shushan "C" concession in which Apache retains 100% interest, logged 178 ft of net pay in the Lower Safa—one of the thickest pay zones in that formation since Apache's 2003 discovery at Qasr.

The well also encountered 45 ft of probable condensate pay in the Jurassic Alam El Bueib (AEB) Unit 6 sand and 30 ft of probable oil pay in the Lower Cretaceous AEB Unit 3.

"Although the accumulation is not as large as Qasr, the Hydra-1X penetrated the same Lower Safa sandstone that we discovered 25 miles away at Qasr—the largest field we've ever discovered, with estimated proved reserves of 2.3 tcf of gas and 80.4 million bbl of condensate," Apache said.

The latest discovery extends the known Lower Safa production trend across Apache acreage an additional 9 miles north of the Kahraman B-22 Lower Safa discovery, which flowed 16 MMcfd of gas and 480 b/d of condensate after fracture stimulation when it was tested in October 2006.

Separately, in Australia, the Brulimar-1 well in Commonwealth waters on the North West Shelf encountered 113 ft of net pay in the Upper Triassic Mungaroo sandstone. Brulimar-1 is the fourth consecutive exploration success on the WA-356-P block. Apache, with a 65% interest, operates that block in a joint venture with Kuwait Foreign Petroleum Exploration Co.

TNK-BP lets contract for Kamennoi field

TNK-BP has awarded to Gulf Interstate Engineering Co., Houston, a contract to provide engineering services for the early planning stages of the Kamennoi field development project involving seven oil and gas fields in Russia.

The first phase of the project anticipates the recovery of 30 million tons of oil, with 330 wells being drilled. An export pipeline and additional oil processing facility will be built.

The second phase involves long-term development of the most reliable reserves.

Gulf Interstate will assist TNK-BP in the early planning stages of this major oil and gas producing field. The firm is to compare development alternatives to determine the optimum configuration and recommended sequence of field development. It also will provide a technical, commercial, and planning basis for subsequent stages and developments.

Second zone tests gas off eastern Trinidad

A second zone has tested gas at an exploratory well 60 miles off eastern Trinidad.

A group led by Canadian Superior Energy Inc., Calgary, said the Victory well on Intrepid Block 5(c) averaged more than 30 MMscfd on a restricted basis at high pressures. The first zone, also on restricted test, gauged 40-45 MMscfd plus condensate (OGJ Online, Jan. 15, 2008).

The group has identified possible other prospective horizons in the well that will be evaluated in other planned wells. The second well, Bounty, is to spud by mid-February.

Participating with Canadian Superior are BG International Ltd. and Challenger Energy Corp., another Calgary independent.

Petro-Canada group finds Moray Firth oil

A group led by Petro-Canada made a potentially commercial discovery 110 km north of Aberdeen, Scotland, in the UK North Sea's Inner Moray Firth area.

The 13/21b-7 well went to TD 2,398 m in 89 m of water and found oil in two Lower Cretaceous sandstone reservoirs. Wireline samples tested 34.5° gravity oil in the deeper reservoir with a 21-m gross column.

The shallower reservoir drillstem tested 21° gravity clean oil at unassisted rates of up to 200 b/d. Petro-Canada said, "Evaluation of the test data indicates that this reservoir has the potential to yield commercial flow rates through the application of horizontal wells and appropriate completion technology."

It is the first exploration commitment well on acreage awarded to Petro-Canada in the UK 23rd round in December 2005.

Interests are Petro-Canada operator with 50%, Samson North Sea Ltd. 35%, First Oil Expro Ltd. 10%, and Reach Exploration (UK) Ltd. 5%. ✦

Drilling & Production — *Quick Takes*

TCO consortium starts up Tengiz field extension

Chevron Corp. affiliate Tengizchevroil LLP, a joint venture of Chevron 50%, KazMunaiGas 20%, ExxonMobil Kazakhstan Ventures Inc. 25%, and LukArco 5%, has started up new facilities as part of the first phase of its expansion at Tengiz field in Kazakhstan.

The total capacity of the TCO consortium will increase to a total of 400,000 b/d following the first phase expansion of 90,000 b/d, while the start-up of full facilities in this year's second half will further increase production capacity to 540,000 b/d.

The start-up includes the sour gas injection project, which reinjects produced sour gas into the reservoir at high pressure to boost production, as well as the front end of the second-generation plant.

According to Chevron, the second-generation plant was brought up to about one third of its full capacity and is currently separating gas for injection while stabilizing and sweetening the oil. Once fully online, the plant also is designed to process sour gas into gas products and elemental sulfur.

When the plant is fully fuctional, about a third of the sour gas produced from the expansion will be injected into the reservoir. The remaining volumes will be processed as commercial gas, propane, butane, and sulfur.

In 2007, the TCO consortium was the largest oil producer in Kazakhstan, with output of 13.93 million tonnes of oil, or 20% of the country's total production. The country's overall oil production rose 3.7% in 2007, according to government figures.

Eni to start Nikaitchuq oil production in 2009

Eni SPA will spend $1.45 billion developing Nikaitchuq oil field off Alaska's North Slope. Field production is scheduled to begin at yearend 2009.

The field, in about 3 m of water, will have 35 production wells and 35 injection wells drilled in it, "about one third of which will be drilled from onshore and the remainder drilled from an offshore artificial island built 4.5 km from the coast," Eni said.

Production will be sent to a newly built 40,000 b/d processing facility onshore near the field and then transported some 22 km to the Kuparuk network, which is linked to the Trans-Alaska Pipeline System.

Nikaitchuq has reserves estimated at 180 million bbl of oil. This will be the first project that Eni will develop in Alaska after acquiring a 30% stake from Armstrong Oil & Gas' Alaskan assets and the remaining 70%, together with operatorship, from Anadarko Petroleum Corp. in first quarter 2007.

In this year's first half Eni expects to begin production in Alaska from Oooguruk field (Pioneer 70% and operator Eni 30%), which also is on the North Slope about 25 km west of Nikaitchuq.

Mexico's oil production down 5.3% in 2007

Mexico's oil production fell by 174,000 b/d or 5.3% in 2007 to an average of 3.08 million b/d, according to state-owned Petroleos Mexicanos, which said the drop was due to inclement weather and an expected decline in the Cantarell complex in the Gulf of Mexico.

Pemex said its production of super-light crude was greater than expected along the coast of Tabasco state, and output in the Ku-Maloob-Zaap region, also in the Gulf of Mexico, exceeded forecasts.

Meanwhile, the energy ministry is expecting Cantarell's crude production to decline gradually over the next 3 years and then sharply, beginning in 2011.

The most serious weather events of 2007 were Hurricane Dean's passage through the Gulf of Mexico in August, which forced bridges to be shut down, and cold fronts in October that forced a halt to operations for several days.

Pemex posted $38 billion in foreign oil sales, up 9.3% over 2006, while exports by volume averaged 1.68 million b/d. The company earned some $44.05 billion from domestic sales, 9.6% more than last year. Mexico is the No. 2 foreign supplier of oil to the US. ✦

Processing — *Quick Takes*

NNPC to restart 125,000 b/d Warri refinery

Nigeria National Petroleum Corp. will restart operations at its 125,000 b/d refinery in Warri in southwest Nigeria on Feb. 6, a company spokesman told OGJ. The refinery has been idle for the past 2 years.

If the restarted refinery works consistently, and at a high throughput, Nigeria's importation of petroleum products will fall significantly. In the beginning, the Warri facility will operate at 70% of capacity.

Vandalism had halted feedstock from being transported to the refinery through the Chanomi Creek Channel pipeline, and NNPC found it difficult to hire international companies to carry out repairs because of safety fears and rising costs (OGJ Online, Aug. 7, 2007). Repairs by a local company were reported to have cost $100 million.

NNPC wholly owns the Warri refinery and also owns two refineries at Port Harcourt, with a total capacity of 210,000 b/d, as well as the 110,000 b/d Kaduna refinery. None of these facilities is operating at capacity. These facilities were sold last year to Blue Star Consortium, but the sale was revoked by President Umaru Yar'Adua after NNPC told the National Assembly it could fix them.

Port Harcourt's fluid catalytic cracking unit has been damaged by power surges, and the Kaduna refinery, which also shares the Chanomi Creek Channel pipeline, is without feedstock. Crude is expected to reach Kaduna within the next 3 weeks after Warri is restarted.

In August the Department for Petroleum Resources received 26 applications from private companies wishing to build refineries in Nigeria (OGJ Online, Aug. 20, 2007).

Petroperu to upgrade Talara refinery

Peru's state-owned Petroperu, in an effort to increase output by

as much as 50%, announced plans to modernize its largest refinery this year. Bidding is to begin in March.

Upgrading northern Peru's Talara refinery, which is expected to cost $1 billion, will increase its oil production capacity to 90,000 b/d from 62,000 b/d, according to Petroperu Pres. Cesar Gutierrez.

Work on the renovation is expected to begin in June, said Gutierrez, who added that Brazil's state-run Petroleo Brasileiro SA will serve as a consultant on the project.

JAC Singapore aromatics project moves ahead

Jurong Aromatics Corp., Singapore, reported UOP LLC, Des Plaines, Ill., is under way with the basic engineering and design of Jurong's planned aromatics plant in Singapore. The project's financing is being finalized, and SK Engineering & Construction is expected to begin construction in this year's first half.

When it starts up in 2011, the complex will produce about 1.5 million tonnes of petrochemicals, including 800,000 tonnes of paraxylene, 200,000 tonnes of orthoxylene, and 450,000 tonnes of benzene. The complex also will have a $400 million condensate splitter and will produce about 2.5 million tonnes of petroleum products such as jet fuel and kerosine.

StatoilHydro puts out fire at Mongstad refinery

StatoilHydro AS has launched an internal investigation after a fire broke out in a coupling flange at its 186,000 b/d Mongstad, Norway, refinery on Jan. 23.

The fire was extinguished and the refinery is now operating at about 75% of its capacity, a company spokesman told OGJ, adding, "It's a bit early to say what the damage was, and the cause of the fire hasn't yet been identified."

No personnel were injured during the fire and StatoilHydro has informed the Petroleum Safety Authority Norway about the incident. ✦

Transportation — *Quick Takes*

Talisman, CNOOC settle over Tangguh project

Talisman Energy Inc. has settled a legal dispute with CNOOC Ltd. over Indonesia's Tangguh LNG project, according to reports.

China Business News said Talisman will pay $40 million to CNOOC for a 2% stake in the BP PLC-led project, which will supply CNOOC's Fujian LNG terminal.

According to earlier reports sent through Talisman's Fortuna Resources unit, Talisman had claimed the right to 44% of CNOOC's 17% interest in the Tangguh project. Lawrence Bernstein, senior manager for exploration at Talisman's Malaysian unit, told China Business News he believed the dispute had been settled, although he had yet to be officially notified.

The reported settlement coincided with news that CNOOC has started building two new gas storage tanks at its Fujian LNG terminal. The two tanks, expected to be completed in 2011, will boost the terminal's storage capacity to 640,000 cu m, the company said in a statement.

Phase I of the Fujian LNG terminal, which involves total investment of 21.9 billion yuan, includes two new gas storage facilities; three gas-fired electric power plants in Putian, Jinjiang, and Xiamen; and distribution facilities in five cities.

CNOOC signed a deal in 2006 to source gas for the Fujian terminal from BP's Tangguh field in Indonesia, which is due to start operating in 2009.

The company will supply 2.6 million tonnes/year of LNG for 25 years to Fuzhou, Putian, Quanzhou, Xiamen and Zhangzhou, and will also supply the fuel for three gas-fired power plants in the province.

StatoilHydro extends Snohvit start-up period

StatoilHydro has asked the Norwegian Pollution Control Authority for a permit to emit more carbon dioxide as it seeks an extension for the start-up period at the Snohvit LNG project near Hammerfest.

Unexpected repairs to leaks in the cooling system have affected the 6-10 month start-up timetable to increase LNG production, and StatoilHydro is now unsure how long it will take. Gas production, which began last September, is expected to plateau at 5.7 billion cu m/year.

A StatoilHydro spokesman told OGJ that Snohvit will run at reduced capacity—about 60%. "But there's great uncertainty around this," he said. Efforts are under way to ensure that Snohvit will run at full capacity in 2009.

Ordinarily the plant would emit 200,000 million tonnes/year of carbon but StatoilHydro estimates this could jump to 1.5 million tonnes/year of CO_2 and 2,200 tonnes of soot during the start-up period. Reduced capacity utilization and other possible modifications have resulted in higher carbon emissions during the start-up.

Total appeals Erika tanker verdict

Total SA said it will appeal the Jan. 16 Paris Criminal Court verdict concerning the sinking of the Erika tanker off Brittany. The vessel, which was chartered by Total, sank in December 1999 and polluted the coastline with 20,000 tonnes of heavy fuel oil.

Total did not dispute, however, the €375,000 fine to compensate the victims for "ecological damage" of the pollution. In a press release, Total said it would ensure payments were made "immediately" and are "full and final whatever the result of the appeal."

Total said it has already spent €200 million in cleaning efforts. Total is disputing the part of the verdict requiring it to pay €192 million in damages for causing the ship to sink. The court said these damages were caused "through lack of care during the tanker-selection process." Total said it was misled by the certification company, Rena, on the tanker's true condition.

"Total is merely a user of ships. It is not its role or its business to act as a substitute for inspection companies and classification societies, the ship owners, or the flag state," the company said.

Christophe de Margerie, Total chief executive officer, said, "We are not happy to appeal. This judgment is aimed at 'the deep pockets'...but in no way does it contribute to rendering the whole maritime chain more responsible." ✦

Letters

World decline rate

The Jan. 17, 2008, press release by Cambridge Energy Research Associates (see www.cera.com), which was carried by Reuters, reported the world's oil supplies were to rise to 112 million b/d by 2017. This rise is in spite of CERA's other conclusion that the world's oil fields are declining in capacity at the average rate of 4.5%/year. These conclusions are clearly suspect.

Although it is unlikely that global oil production is likely to drop significantly in the next few years, major sustainable increases are equally unlikely. Given the current global production of 86 million b/d and CERA's 4.5% decline rate, global capacity would have to increase by 7.5 million b/d each year for the next 10 years to reach 112 million b/d. This is a total of 75 million b/d of new capacity in 10 years. Even excluding the effect of declining rates, achieving 112 million b/d within a decade represents a massive leap of 26 million b/d in global capacity.

To put this in perspective, 75 million b/d of new capacity is the equivalent of eight new Saudi Arabias or 14 new Irans in just 10 years. Considering the reality that Saudi Arabia, with 25% of the world's best proven reserves, is already investing $50 billion to increase its production capacity by 2 million b/d, where does CERA expect the additional 24 million b/d of production capacity to come from, let alone the replacement for the 51 million b/d of declines?

Dr. Moujahed Al-Husseini
GeoArabia
Manama, Bahrain

Dr. Sadad Al-Husseini
Saudi Aramco (retired)
Dhahran

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✦ Denotes new listing or a change in previously published information.

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2008

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IADC Health, Safety, Environment & Training Conference & Exhibition, Houston, (713) 292-1945, (713) 292-1946 (fax), e-mail: conferences@iadc.org, website: www.iadc.org. 5-6.

SPE Unconventional Reservoirs Conference, Keystone, Colo., (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 10-12.

International Pipeline Pigging & Integrity Management Conference & Exhibition, Houston, (713) 521-5929, (713) 521-9255 (fax), e-mail: clarion@clarion.org, website: www.clarion.org. 12-14.

Deep Offshore Technology International Conference & Exhibition, Houston, (918) 831-9160, (918) 831-9161 (fax), e-mail: registration@pennwell.com, website: www.dotinternational.net. 12-14.

SPE International Formation Damage Control Symposium & Exhibition, Lafayette, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 13-15.

Alternative Fuels Technology Conference, Prague, +44 (0) 20 7357 8394, +44 (0) 20 7357 8395 (fax), e-mail: Conferences@EuroPetro.com. website: www.europetro.com. 18.

IP Week, London, +44 (0)20 7467 7100, +44 (0)20 8561 0131 (fax), e-mail: events@energyinst.org.uk, website: www.ipweek.co.uk. 18-21.

International Catalyst Technology Conference, Prague, +44 (0) 20 7357 8394, +44 (0) 20 7357 8395 (fax), e-mail: Conferences@EuroPetro.com. website: www.europetro.com.19-20.

Pipe Line Contractors Association Annual Conference (PLCA), Maui, (214) 969-2700, (214) 969-2705 (fax), e-mail: plca@plca.org, website: www.plca.org. 20-24.

International Petrochemicals & Gas Technology Conference & Exhibition, Prague, +44 (0) 20 7357 8394, +44 (0) 20 7357 8395 (fax), e-mail: Conferences@EuroPetro.com. website: www.europetro.com. 21-22.

AAPG Southwest Section Meeting, Abilene, Tex., (918) 560-2679, (918) 560-2684 (fax), e-mail: convene@aapg.org, website: www.aapg.org. 24-27.

Laurance Reid Gas Conditioning Conference, Norman, Okla., (405) 325-3136, (405) 325-7329 (fax), e-mail: bettyk@ou.edu, website: www.lrgcc.org. 24-27.

Middle East Refining Conference & Annual Meeting, Abu Dhabi, +44 (0) 1242 529 090, +44 (0) 1242 529 060 (fax), e-mail: wra@theenergyexchange.co.uk, website: www.wraconferences.com. 25-26.

CERI Natural Gas Conference, Calgary, Alta., (403) 220-2380, (403) 284-4181 (fax), e-mail: jstaple@ceri.ca, website: www.ceri.ca. 25-26.

SPE Intelligent Energy Conference & Exhibition, Amsterdam, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 25-27.

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conferences@iadc.org, website: www.iadc.org. 26-27.

Middle East Fuels Symposium, Abu Dhabi, +44 (0) 1242 529 090, +44 (0) 1242 529 060 (fax), e-mail: wra@theenergyexchange.co.uk, website: www.wraconferences.com. 27-28.

MARCH

GPA Annual Convention, Grapevine, Tex., (918) 493-3872, (918) 493-3875 (fax), e-mail: pmirkin@gasprocessors.com, website: www.gasprocessors.com. 2-5.

GEO Middle East Geosciences Conference & Exhibition, Bahrain, +44 20 7840 2139, +44 20 7840 2119 (fax), (fax), e-mail: geo@oesallworld.com, website: www.allworldexhibitions.com. 3-5.

Subsea Tieback Forum & Exhibition, Galveston, Tex., (918) 831-9160, (918) 831-9161 (fax), e-mail: registration@pennwell.com, website: www.subseatiebackforum.com. 3-5.

NPRA Security Conference, The Woodlands, Tex., (202) 457-0480, (202) 457-0486 (fax), e-mail: info@npra.org, website: www.npradc.org. 4-5.

ARTC Annual Meeting, Bangkok, +44 1737 365100, +44 1737 365101 (fax), e-mail: events@gtforum.com, website: www.gtforum.com. 4-6.

Global Petrochemicals Annual Meeting, Dusseldorf, +44 (0) 1242 529 090, +44 (0) 1242 529 060 (fax), e-mail: wra@theenergyexchange.co.uk, website: www.wraconferences.com. 4-6.

IADC/SPE Drilling Conference & Exhibition, Orlando, (713) 292-1945, (713) 292-1946 (fax); e-mail: conferences@iadc.org, website: www.iadc.org. 4-6.

SPE Indian Oil & Gas Technical Conference & Exhibition, Mumbai, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 4-6.

Annual Middle East Gas Summit, Doha, +971 4 336 2992, +971 4 336 0116 (fax), e-mail: sarita.singh@ibc-gulf.com, website: www.ibcgulfconferences.com. 5-6.

NPRA Annual Meeting, San Diego, (202) 457-0480, (202) 457-0486 (fax), e-mail: info@npra.org, website: www.npradc.org. 9-11.

World Heavy Oil Congress, Edmonton, Alta., (403) 209-3555, (403) 245-8649 (fax), website: www.petroleumshow.com. 10-12.

New Zealand Petroleum Conference, Auckland, +64 3 962 6179, +64 4 471 0187 (fax), e-mail: crown.minerals@med.govt.nz, website: www.crownminerals.govt.nz. 10-12.

Gastech International Conference & Exhibition, Bangkok, +44 (0) 1737 855005, +44 (0) 1737 855482 (fax), e-mail: tonystephenson@dmgworldmedia.com, website: www.gastech.co.uk. 10-13.

API Spring Petroleum Measurement Standards Meeting, Dallas, (202) 682-8000, (202) 682-8222 (fax), website: www.api.org/events. 10-14.

European Fuels Conference & Annual Meeting, Paris, +44 (0) 1242 529 090, +44 (0) 1242 529 060 (fax), e-mail: wra@theenergyexchange.co.uk, website: www.wraconferences.com. 11-12.

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NACE International Conference & Expo, New Orleans, (281) 228-6200, (281) 228-6300 (fax), website: www.nace.org. 16-20.

Offshore Asia Conference & Exhibition, Kuala Lumpur, (918) 831-9160, (918) 831-9161 (fax), e-mail: registration@pennwell.com, website: www.offshoreasiaevent.com. 17-19.

Sub-Saharan Oil, Gas & Petrochemical Exhibition & Conference, Cape Town, +27 21 713 3360, +27 21 713 3366 (fax), e-mail: expo@fairconsultants.com, website: www.fairconsultants.com. 17-19.

Turoge and Black Sea Oil & Gas Exhibition & Conference, Ankara, +44 207 596 5016, e-mail: oilgas@ite-exhibitions.com, website: www.ite-exhibitions.com/og. 18-20.

AAPG Prospect & Property Expo (APPEX), London, (918) 560-2679, (918) 560-2684 (fax), e-mail: convene@aapg.org, website: www.aapg.org. 24-26.

AAPG Pacific Section Meeting, Bakersfield, Calif., (918) 560-2679, (918) 560-2684 (fax), e-mail: convene@aapg.org, website: www.aapg.org. Mar. 29-Apr. 2.

NPRA International Petrochemical Conference, San Antonio, (202) 457-0480, (202) 457-0486 (fax), e-mail: info@npra.org, website: www.npradc.org. Mar. 30-Apr. 1.

SPE Middle East Petroleum Engineering Colloquium, Dubai, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. Mar. 30-Apr. 2.

PIRA Understanding Global Oil Markets Conference, Tokyo, (212) 686-6808, (212) 686-6628 (fax), e-mail: sales@pira.com, website: www.pira.com. Mar. 31-Apr. 1.

ERTC Sustainable Refining Conference, Brussels, +44 1737 365100, +44 1737 365101 (fax), e-mail: events@gtforum.com, website: www.gtforum.com. Mar. 31–Apr. 2.

APRIL

SPE/ICoTA Coiled Tubing & Well Intervention Conference & Exhibition, The Woodlands, Tex., (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 1-2.

ERTC Biofuels+ Conference, Brussels, +44 1737 365100, +44 1737 365101 (fax), e-mail: events@gtforum.com, website: www.gtforum.com. 2-4.

GIOGIE Georgian International Oil & Gas Conference & Showcase, Tbilisi, +44 207 596 5016, e-mail: oilgas@ite-exhibitions.com, website: www.ite-exhibitions.com/og. 3-4.

Middle East Petroleum & Gas Conference, Doha, +65 6222 0230, +65 6222 0121 (fax), e-mail: mpgc@cconnection.org, website: www.cconnection.org. 6-8.

ACS National Meeting & Exposition, New Orleans, 1 (800) 227-5558, e-mail: natlmtgs@acs.org, website: www.acs.org. 6-10.

American Institute of Chemical Engineers (AIChE) Spring National Meeting, New Orleans, (212) 591-8100, (212) 591-8888 (fax), website: www.aiche.org. 6-10.

CIOGE China International Oil & Gas Conference, Beijing, + (44) 020 7596 5000, + (44) 020 7596 5111 (fax), e-mail: oilgas@ite-exhibitions.com, website: www.ite-exhibitions.com/og. 7-8.

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API Spring Refining & Equipment Standards Meeting, New Orleans, (202) 682-8000, (202) 682-8222 (fax), website: www.api.org/events. 14-16.

API/NPRA Spring Operating Practices Symposium, New Orleans, (202) 682-8000, (202) 682-8222 (fax), website: www.api.org/events. 15.

SPE Gas Technology Symposium, Calgary, Alta., (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 15-17.

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SPE Improved Oil Recovery Symposium, Tulsa, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 20-23.

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WestAsia Oil, Gas, Refining, & Petrochemicals Exhibition & Conference, Oman, +968 24790333, +968 24706276 (fax), e-mail: clemento@omanexpo.com, website: www.ogwaexpo.com. 21-23.

International Pump Users Symposium, Houston, (979) 845-7417, (979) 847-9500 (fax), website: http://turbolab.tamu.edu. 21-24.

SPE Progressing Cavity Pumps Conference, Houston, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 27-29.

MAY

IOGCC Midyear Meeting, Calgary, Alta., (405) 525-3556, (405) 525-3592 (fax), e-mail: iogcc@iogcc.state.ok.us, website: www.iogcc.state.ok.us. 4-6.

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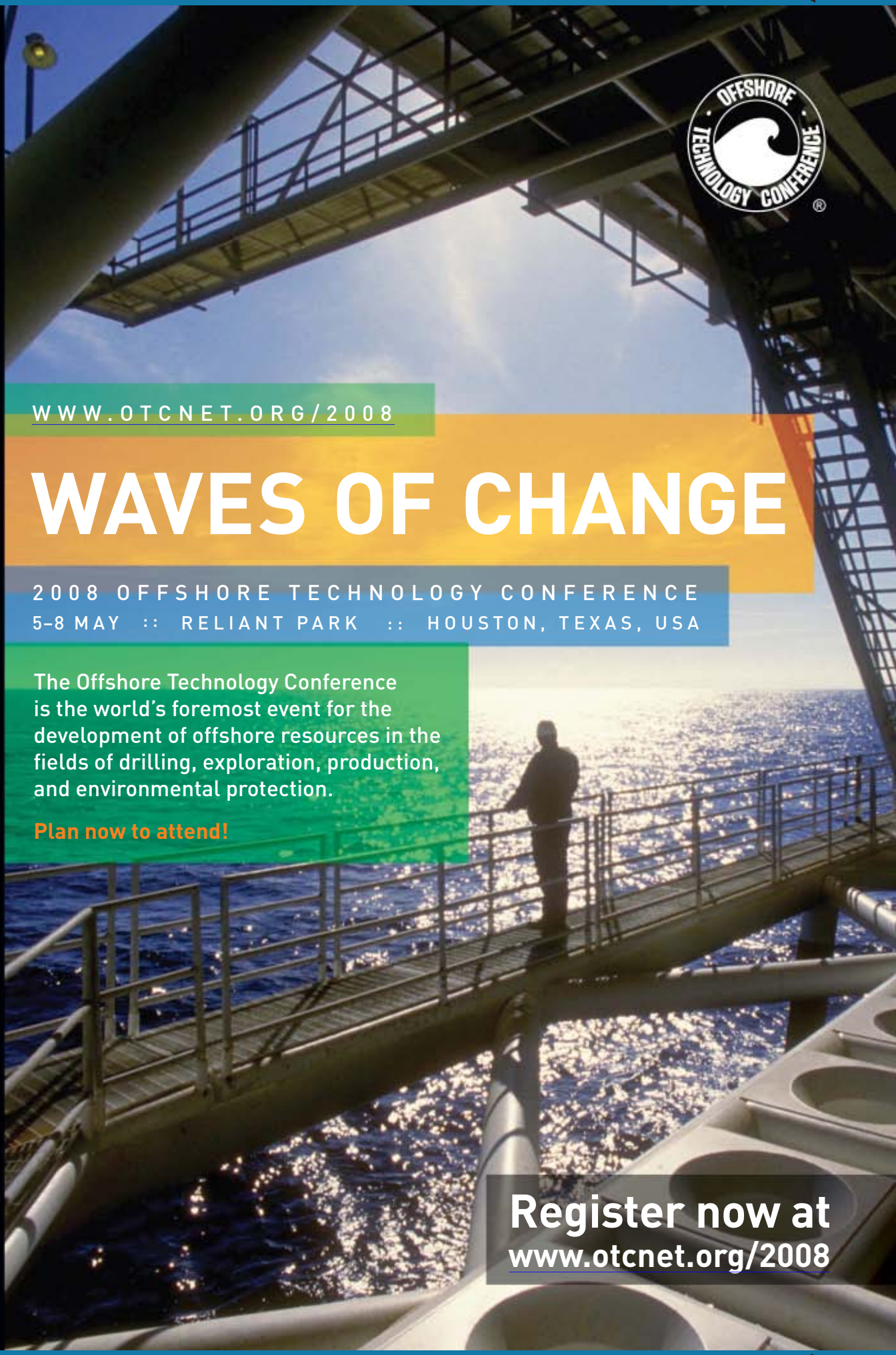
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The knowledge base

Steven Poruban
Senior Editor

The oil and gas industry's worry over the loss of its petroleum engineering and geological knowledge base to an expected wave of retirements may not be as warranted as once thought. At least a recent announcement by the Society of Petroleum Engineers may nudge some toward thinking so.

In late January SPE reported that its membership had reached a record high. At yearend 2007 SPE's combined worldwide professional and student membership reached 79,300, up 8% from yearend 2006. The organization's membership has, in fact, climbed steadily over the last several years, rising 23% since 2004.

One of the more notable—and encouraging—facts about this steady membership climb is the rise in the number of SPE members under age 35, SPE said. At yearend 2007, 21% of SPE members, or 12,716, were under 35, up from 20% in 2006 and 14% in 2000, SPE said.

Much of this growth is attributable to a rise in total student members, which at yearend 2007 reached a record 18,700 compared with 16,800 at yearend 2006. Total professional members of SPE, meanwhile, also showed a gain, reaching 60,600 in 2007 vs. 56,500 a year before.

SPE said the increase in young professionals and students is "an important indicator that more young people are entering the upstream industry," thus helping to reverse the aging of the profession.

Bill Cobb, 2008 SPE president, noted, "We are especially pleased with the 11% increase in student members, which shows that young people are attracted by the bright career opportunities in the upstream industry." While viewing the recent data optimistically, Cobb added, "I don't think we can draw conclusions about the entire industry from our membership statistics, but what is clear is that there are large numbers of young professionals entering the industry, which is something that is sorely needed."

Regional breakdown

Interesting also was the regional breakdown of SPE's 2007 membership. SPE members, who come from 110 countries, increased in practically every region in 2007, SPE said, with the largest growth occurring in the Middle East region, including India. Membership from this region increased 15% to 6,827.

Other areas showing a boost in membership in 2007 vs. 2006 included the Northern Asia-Pacific region, including China, up 10% to 3,699; the Rocky Mountain North America region, up 9% to 6,069; and the South-Central and Eastern Europe region, including Russia, up 7% to 3,114.

SPE said areas with new sections include Mauritania, Brazil, Chad, India, and two in the US: Seattle and Grand Junction, Colo.

New chapters were added at universities in Russia, Bangladesh, Brazil, Iran, Congo, Nigeria, the UK, Canada, and Qatar, bringing to 179 the number of SPE student chapters—150 of them outside the US.

Courting youth

Many oil companies work to capture and keep young people's interest in the industry. It is oil companies as well that help to fund industry organizations.

Chevron Corp., for one, sponsors the SPE student membership program and is underwriting the university student annual membership dues for the next 2 years.

Attracting young talent is not limited to the US, of course. One example occurred Jan. 26-28 when 14 graduate students from Massachusetts Institute of Technology were flown on a Saudi Aramco plane to Shaybah oil and gas field to visit the company's facilities.

The students, all members of the MIT Energy Club, represented disciplines including mechanical engineering, business management, and geothermal energy. Their itinerary included tours of the remote Shaybah complex and the Ras Tanura refinery.

An Aramco company publication reported that the students left Saudi Arabia impressed with the area and the company. Between tours there were sand-dune races and sand-castle building. After a traditional meal of kabsa, the visitors received a vial of sand from the dunes.

"I don't need this," Dave Bradwell, a material sciences student, was reported as saying. "I'm taking enough home that's on me."

There's no doubt that the investment of a vile of sand will pay back the company—as well as industry—more than a sandstorm of riches. ✦

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Editorial

Bush's energy program

It's no mere coincidence that the most sterile climate in decades for energy policy-making developed while the US president followed instead of led on the subject. George W. Bush surely knows more than he lets show about energy. He also knows that a Texan president with family roots in the oil and gas business arouses stifling suspicion in the US and that relief comes from speaking against 62% of his country's energy supply.

When Bush disparages oil—and by association natural gas—therefore, it's reasonable to assume the motivation is politics. He doesn't denounce the industry that brings oil to market or the companies or people within it. He confines his scorn to the substance. His measured approach has been enough to hold mostly at bay the detractors who condemn him for any hint of friendliness toward an industry they hate. It also has allowed discussion about energy in the US to become delusional.

Costly turn

A president leads with public pronouncements, which achieve their greatest force in the annual state-of-the-union address. What Bush has said from that platform explains much about a costly US turn on energy. In 2003, promising to "promote energy independence for our country while dramatically improving the environment," he proposed $1.2 billion in research funding for hydrogen-powered vehicles. Through this "important innovation to make our air significantly cleaner and our country much less dependent on foreign sources of energy," Bush set the country back on a course, discredited by history, toward fuel selection by government.

In 2004, Bush urged Congress to pass "legislation to modernize our electricity system, promote conservation, and make America less dependent on foreign sources of energy." The legislature obliged the following year with a bill full of political favors for a range of energy sources, including for oil and gas but more extravagantly for fuels from renewable sources such as ethanol and biodiesel.

With prices high after hurricanes slashed US oil and gas supplies, Bush in January 2006 complained that the US was "addicted to oil." He boasted that the government had spent nearly $10 billion since 2001 "to develop cleaner, cheaper, and more reliable alternative sources" and promised: "We are on the threshold of incredible advances." Announcing further increases in spending for "clean-energy research," he set goals of making ethanol from cellulose commercial within 6 years and replacing 75% of US oil imports from the Middle East by 2025.

In last year's state-of-the-union address, Bush raised the targets. Seeking a 20% cut in gasoline use within 10 years, he called for a quintupling of the mandate for renewable and alternative vehicle fuels to 35 billion gal by 2017 and a toughening of fuel efficiency standards. He again heralded innovation, saying, "America is on the verge of technological breakthroughs that will enable us to live our lives less dependent on oil." And again, Congress obliged him, passing the Energy Independence and Security Act.

The president was more general in his last state-of-the-union speech on Jan. 28. He talked up coal use for power generation with carbon capture, increased use of renewable and nuclear power, advanced batteries and renewable fuels for vehicles, and an "international clean technology fund" to help developing countries increase their use of "clean energy sources."

Programmatic approach

Throughout his presidency, then, Bush has articulated a programmatic approach toward energy that veers away from the market orientation in place since the 1980s. The approach plays to American cravings for domestically produced energy forms that are—or at least appear to be—less polluting than oil. It also ignores American requirements that energy be plentiful and cheap—the very essentials that have doomed past government forays into energy choice.

To his credit, Bush at various times has supported expanded federal leasing and other efforts to raise US production of oil and gas. With his serial acquiescence to popular fantasy, however, he has invited into the national energy discussion an antioil prejudice that consistently forecloses steps his country must take if it is to raise domestic energy supply in large amounts at affordable cost. ✦

Independents mitigate field costs through operating efficiencies

Paula Dittrick
Senior Staff Writer

Independent operators report strong US exploration and production efforts despite increased drilling costs and other service costs. Companies strive to mitigate higher expenses through operating efficiencies, noting that the 2008 field cost outlook is uncertain.

Partially because of rising field costs, Apache Corp. reduced its 2007 US exploration and development budget from its 2006 budget. Yet, the company continues to increase production and add reserves.

This story reviews the methods Apache uses to manage its costs in the Anadarko basin, Permian basin, and East Texas. Devon Energy Corp. provided information about its operations in the Barnett shale and the Rocky Mountains.

Several independents declined to discuss company-specific field costs with OGJ, and some said the information is proprietary.

High service costs can contribute to higher commodity prices. Adam Sieminski, Deutsche Bank chief energy economist, recently revised his 2008 average price forecast for West Texas Intermediate crude on the New York Mercantile Exchange to $85/bbl, up $5/bbl.

"One key factor that offers compelling new evidence that our longer-term energy price forecasts need to be revised higher is rapidly increasing finding and development costs," Sieminski said.

Oil price declines historically follow lower demand for refined products, improvements in seismic and drilling technology, and better access to petroleum reserves, said.

"A repeat of this confluence of events is certainly possible, but seems improbable over the course of the next few years," Sieminski said, citing flourishing oil demand growth in Asia and the Middle East.

JAS shows rising costs

The Joint Association Survey on Drilling Costs (JAS) estimates industry spent $76.2 billion in 2005 to drill and equip wells in the US, up 18% from the estimate for 2004.

Increases in the number of wells and footage drilled pushed the average cost per well and cost per foot to higher levels (see table). The JAS survey relies upon actual well costs provided

JAS EXECUTIVE SUMMARY,[1] 2005 VS. 2004

	Oil wells		Gas wells		Dry holes		Total[2]	
	2005	Change, %	2005	Change, %	2005	Change, %	2005	Change, %
Number of wells	14,275	23.3	25,725	11.7	4,296	4.4	44,296	14.4
Total footage, thousand	87,200	39.4	137,576	9.0	23,910	–2.3	248,686	16.6
Total cost, million $	27,414	64.4	38,526	–2.5	10,280	26.7	76,220	17.6
Average depth, ft	6,109	13.1	5,348	–2.4	5,566	–6.4	5,614	2.0
Average cost/well, $	1,920,420	33.3	1,497,609	–12.7	2,392,924	21.4	1,720,697	2.8
Median cost/well, $[3]	615,000	40.7	472,000	–17.6	378,000	–1.1	513,000	5.6
Average cost/ft, $	314.36	17.9	280.03	–10.5	429.92	29.6	306.50	0.9

[1]2005 Joint Association Survey on Drilling Costs (includes sidetrack wells except where noted). Estimate based upon JAS model. JAS contains most, but not all, of the wells actually drilled and completed in the US during the survey year. A fraction of actual wells during a survey year is reported after the JAS is published. [2]Totals may not agree with the sum of individual items due to rounding. [3]Does not include sidetrack wells.
Source: American Petroleum Institute

by hundreds of operators.

The American Petroleum Institute, Independent Petroleum Association of America, and Mid-Continental Oil and Gas Association sponsor the survey. API analysts have compiled the yearly survey report since 1954.

The survey of 2005 costs was released in April 2007, said Hazem Arafa, API statistics department director.

Survey compilers have about 70% of the data when they begin a report, and they use those field cost reports to estimate the costs for every well in the database, Arafa said. It takes 3 years for 99.7% of the wells drilled to be reported.

"Once we develop the model, we estimate costs," Arafa said. "As wells come in later on, we always can attach a cost to it using the model. We don't resurvey the companies."

Ron Planting, API's manager of statistical information, said API prepares drilling cost indexes that separate out the effects of shifts in drilling depths and regional patterns, as well the effects of general inflation.

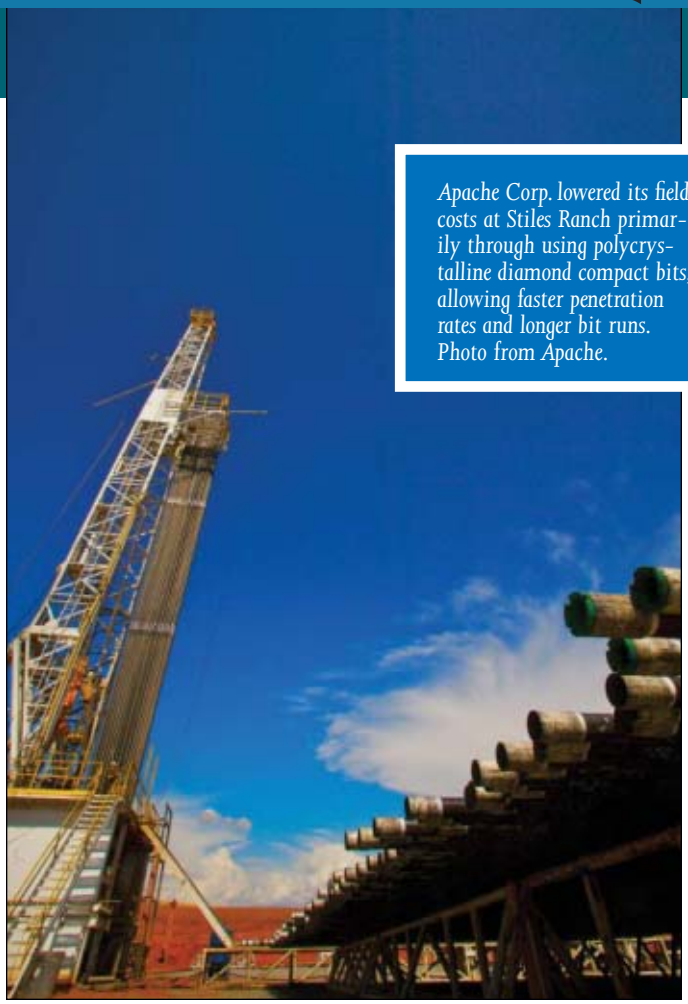
"Without adjusting for these factors, the survey shows that average cost per well more than doubled between 2001 and 2005." Planting said. "Part of that cost increase, however, was due to shifts to deeper drilling and other changes in drilling patterns."

After removing the effects of changes in depth and regional drilling patterns, the API index shows that costs rose 78%. If that is further adjusted for inflation, the JAS indexes show that inflation-adjusted costs rose 68%, Planting said.

API Chief Economist John Felmy noted that companies are continually experiencing higher drilling success rates. He said field costs for 2005 are much different than the costs reported decades ago, in part because the success rate has gone up dramatically.

"Here in Washington, people like to point out you've got $100/bbl oil. But at the same time, you've also got to realize that costs have increased," Felmy said. "It's a challenge for oil companies because you've got costs that are changing dramatically.

Oil companies are looking to go forward and develop resources, but they've got to be sure that they can do it," Felmy said. "Companies are putting projects in place that are going to last 30-40 years, and that just makes it much, much more challenging."



Apache Corp. lowered its field costs at Stiles Ranch primarily through using polycrystalline diamond compact bits, allowing faster penetration rates and longer bit runs. Photo from Apache.

CERA: Costs moderating

Cambridge Energy Research Associates (CERA) said upstream capital costs moderated slightly during the first half of 2007 compare with the rate of cost increases during 2006.

Pritesh Patel, lead researcher on upstream capital costs for CERA, said, "This raised an expectation in the industry that cost increases may be coming to an end." However, he said, "The latest data indicate this not to be the case."

Although rigs are being built and equipment manufacturing capacity is increasing, much of that expansion will not come on line until the second half of 2008 or later.

In November 2007, CERA and its parent IHS Inc. said costs of constructing new oil and gas facilities had surged to a record high, up 11% in 6 months to 198 points on CERA's upstream capital costs index.

"This is nearly double the costs observed as recently as 2005 when the index measured 106 points," CERA said. Analysts did note a slight decline in day rates for offshore drilling rigs.

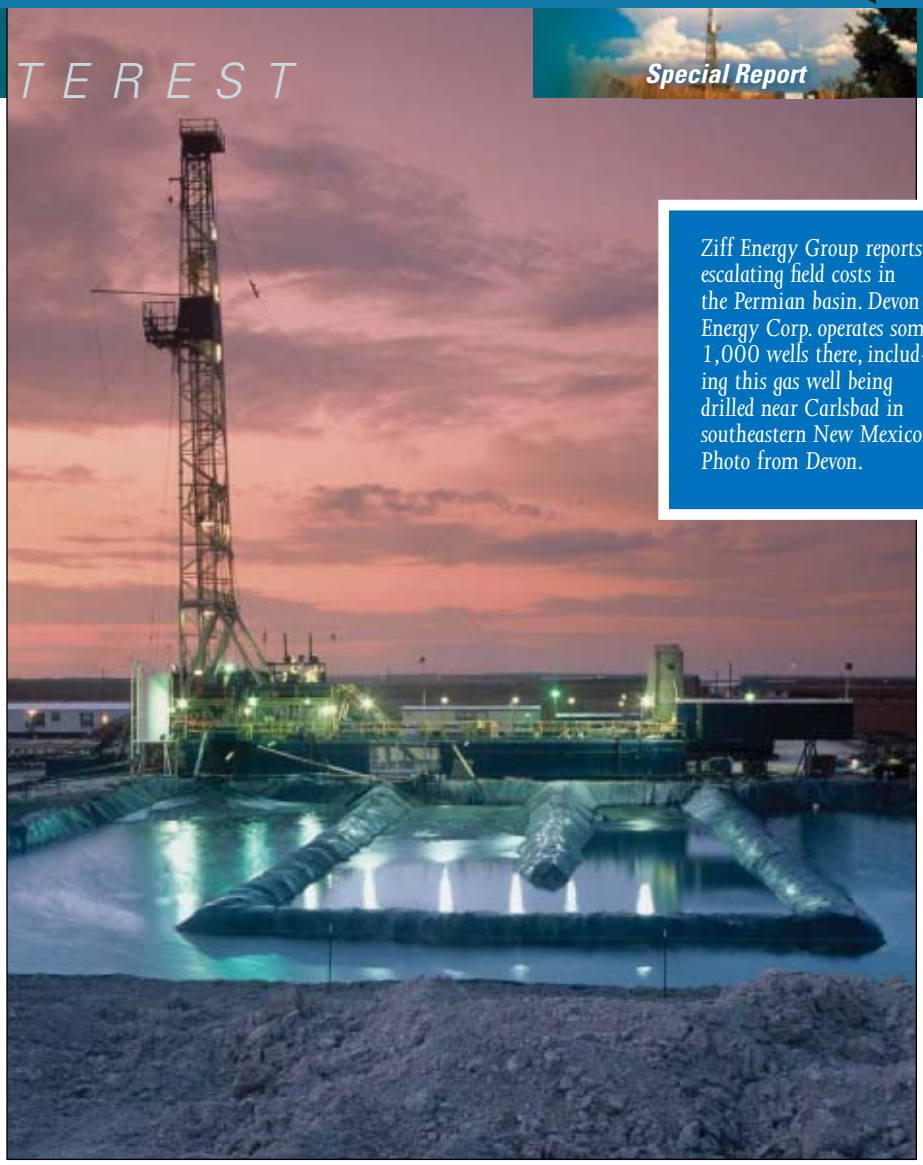
A sustained increase in the price of steel in 2003 followed by rising oil prices triggered a dramatic increase in oil field equipment and facilities in 2005.

"As industry activity levels increased in 2005-06, manufacturers and suppliers of oil and gas equipment and services reached maximum capacity and began to increase their prices," CERA said. The cumulative effect of tight capacity due to high activity levels and high raw-material costs nearly doubled the capital required for the same set of facilities.

Apache lowering costs

Apache combines improved equipment and drilling technology with finely tuned exploration strategies

Tom Voytovich, vice-president of Apache's Central Region, said land rig rates are down 5-10% from their levels a year ago. Rig availability also has improved somewhat from the same time last year, especially for intermediate-sized rigs. New rigs and those with



Ziff Energy Group reports escalating field costs in the Permian basin. Devon Energy Corp. operates some 1,000 wells there, including this gas well being drilled near Carlsbad in southeastern New Mexico. Photo from Devon.

more powerful pumps remain in short supply.

Apache's Central Region waited 3 months to get rigs in early 2007, but the Houston independent's rig wait was only few weeks as of early 2008. Voytovich credits drilling contractors for building rigs so that supply climbed to meet increasing demand.

"Our drilling performance continues to improve, so we are realizing a savings over a year ago across the Midcontinent and Texas," Voytovich said. "We continue to climb the learning curve on technologies and build on our area expertise."

Apache significantly lowered its field costs at Stiles Ranch, primarily through what Voytovich calls "aggressive use" of polycrystalline diamond compact (PDC) bits and through using rigs with top drives.

PDC bits allow Apache to get much faster penetration rates and also much longer bit runs, which saves time because it requires fewer trips.

"What that accomplished is that we now drill wells in significantly less time," Voytovich said. Apache took 50 days to drill 16,000-ft vertical wells in Stiles Ranch in mid-2006, but now it drills a well in 40 days. In January, Voytovich expected Apache would reduce its drilling time there to 37-38 days within a couple of months.

The use of top drives eliminates some steps in pipe handling, reduces nonproductive time, and enables a rig to multitask by being able to rotate and circulate while tripping and running casing.

"This is beneficial when drilling directional wells, and it provides better well control on trips," Voytovich said. "Operational efficiencies achieved through the use of top drives translate directly into cost savings."

Apache lowered drilling costs $200,000/well for Stiles Ranch, which straddles the Oklahoma-Texas border just north of US Interstate 40 and is one of the most active areas for Apache's Central Region. Apache drilled 21 wells in Stiles Ranch during 2007 and expects to drill 25 or more wells there this year.

In East Texas, Voytovich sees rig availability "loosening up a little." He expects Apache will drill about 25 wells there this year. He sees strong demand for drilling rigs capable of drilling horizontal wells in East Texas, which is something that Apache does.

Regarding Midcontinent field costs, Voytovich expects day rates will fluctuate with natural gas prices.

"It has to do with the redistribution of rigs as well," he said. "We lost rigs from Oklahoma and the Texas Panhandle up to the Rockies in the last couple of years. We are starting to see some of those rigs come back. If that continues, we should see prices go down."

Strong rig demand in Permian

Apache plans to drill more than 200 wells this year in the Permian basin, a moderate increase over what it drilled there last year.

"This is really driven by rig availability," Voytovich said. "Permian is an area that is receiving a lot of heat and light right now because of [high] oil prices, so rig availability is a little tighter there."

He noted that smaller rigs in the Permian handle singles only while most rigs hired by Apache use triples. Apache's current contract land fleet includes rigs ranging from 500 hp to 2,000 hp. The fleet involves newbuild rigs having the latest technology and decades-old rigs having had various upgrades and modernization.

Ziff Energy Group reports overall Permian basin operating costs increased 35% since 2004. A recent benchmark-

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ing study, "Improving Field Performance," was Ziff's sixth Permian study since 1996. Five of the six participating operators were independents.

The study examines operating cost data for a 12-month period from mid 2006 to mid 2007. The study assessed 134 fields (including 26 carbon dioxide tertiary enhanced oil recovery fields) that collectively produce nearly half the basin's oil and a third of its natural gas.

Part of the increased average operating costs since 2004 was associated with higher oil and gas prices.

The average operating cost for Permian oil fields increased 34% to $10.42/bbl since last analyzed. Saying that increase was in line with increased oil prices, Ziff also noted that leading operators achieved average oil field operating costs below $6.50/bbl.

The average operating cost for gas fields increased 45% to nearly $1.35/Mcf. By contrast, leading operators of gas fields achieved average operating costs of less than 80¢/Mcf.

"Unlike the oil price, however, the gas price has hardly increased, so gas margins are squeezed," Ziff said.

Ziff analysts concluded that electricity costs increased 40% and that taxes constituted the largest single cost component for both oil and gas fields (40% for gas fields, and almost a third of total operating expenses for oil fields).

"Cost pressures and reduction potential are heavily concentrated in four specific cost categories: well servicing, taxes, labor and field supervision, and electricity," Ziff said.

Rocky Mountain costs

Operating costs in the Rocky Mountains vary dramatically because of weather, remote locations, and water production from coalbed gas wells, Devon said. Labor, transportation, and compression costs also are higher in the Rockies.

Devon's Rocky Mountain operations involve various types of wells drilled. Some wells are shallow, conventional wells while others are deeper or coalbed gas wells. The company's Rocky Mountain operations stretch from northern New Mexico up through parts of Colorado, Utah, Wyoming, and Montana.

In the Washakie basin in Sweetwater County, Wyo., Devon said wells averaged $2.5 million compared with $2.2-2.3 million about 18 months ago.

In 2007, Devon drilled about 130 conventional wells and 200 coalbed gas wells in the Rockies.

"This year, we expect to drill 100-150 conventional wells and about 100 coalbed natural gas wells in the area," the company told OGJ. "Devon's capital budget in the Rockies is about $300 million for 2008."

Devon is very active in the Barnett shale near Fort Worth, Tex. In 2007, Devon drilled 524 wells there, and it anticipates drilling about the same number this year. The 2008 capital budget for the Barnett shale is $1.4 billion.

"The average cost to drill a horizontal well in the Barnett shale is about $2.5-3.5 million," Devon said. "However, we continue to improve our efficiency and keep our costs in the play relatively flat. For example in 2004, the average Barnett horizontal well took 33.4 days from spud to rig release. In 2007, we averaged 16.7 days/well."

In very general terms, Devon listed the following costs in descending order for an average Barnett shale horizontal well's cost: stimulation, rig time, directional services, casing and tubulars, logging services, and drillbits. ✦

High costs for rigs, services pinch independents

Sam Fletcher
Senior Writer

High costs for drilling rigs and services are expected to continue in 2008 in an already tight market for equipment and personnel, say industry analysts and independent oil and gas producers.

"Drilling costs escalated early in 2007, then reduced in the second quarter as more land rigs joined the fleet," said Bill Stevens, executive vice-president of the Texas Alliance of Energy Producers in its Austin and Abilene offices.

TAEP is the largest state oil and gas trade association in the nation, with more than 3,000 members. Although no official survey has been made, Stevens said, "The anecdotal evidence is that the acceleration of drilling costs has eased some, if not idled back."

In the alliance's Houston office, Pat French, senior vice-president, said, "After strong cost increases in 2005-06, independents generally expected more muted drilling costs in 2007. Many think drilling costs may have plateaued late in 2007, even at a relatively high rate." French told OGJ, "People still are very concerned about prices for equipment and services, but a number of factors are involved. Finding personnel continues to be a real problem for drilling contractors."

On the other hand, French sees "a growing rig supply as a result of more

rigs coming down from Canada," which is experiencing a drilling slump.

French also cited "major concerns about the economic outlook" among independents. "There is a lot of uncertainty about the future direction of the economy, and that is having an impact." he said. "It's a very sensitive market at this point. Weather will be a wild card in 2008."

Many independent producers were affected when natural gas prices slipped below $6/MMbtu a few months ago, causing some producers to curtail gas exploration and production. "People are cutting back on gas. Production costs have rescinded, but the price of gas has not sustained like the price of oil," said Stevens.

French said, "Gas production in the US and Canada, LNG imports, and high gas storage levels all impact independents. They are going to be more conservative. However, a slowdown in gas production could very well lead to an upturn in the second half."

The connection between the oil and gas markets has changed to a 10-12:1 economic value of oil to gas vs. the traditional energy content ratio of 6:1. "Of course," Stevens said, "independents get much lower prices at wellhead than on the spot and futures markets." In addition to the cost of rigs and services, independents' income is pinched by increased costs of leases and pipeline transportation.

With crude futures market prices now above $90/bbl on the New York market, French said, "I would not be surprised to see more independents drilling for oil than we have seen for some time." He said, "The key indicator is the rig count. The dominant feeling is that the count will stay strong, and there is a significant amount of optimism for improvement in the second half of the year."

Yet despite high oil prices, Stevens said, "Only 10-15% of rigs are drilling for crude." There are "not a lot of workovers" to improve production of existing wells. And despite a bigger rig fleet, he said, "People are still waiting for rigs and other services in other areas as more men and equipment have flowed to the Barnett shale. Permian basin consolidations have left people standing in line for equipment and services."

Political problems blamed

At the Texas Alliance's exposition and annual meeting in April 2007, Roy T. Pitcock, president of Pitcock Inc. in Graham, Tex., summed up the major problem for independents in just one word: "Politicians."

"They're not looking after us as they should," Pitcock said. "They're looking after themselves. I don't have a problem with people looking after themselves, but they're not paid to do that. They should be looking after the problems for their districts in the right way, where the funds come for the school systems in their areas. All we're asking is to get government off our backs; 98% of the independents are doing their best to give people jobs."

Pitcock told OGJ, "Costs are higher than a year ago. Expenses and labor have gone up. It does slow us down, but the price of oil is a lot higher too."

When it comes to looking at prospects and deciding how many wells to drill, he said, "You still look at the economics. Of course, we used to have our own drilling fleet in the 1960s-1970s, but we sold them all. It would be nice to have them back—everybody wants a rig." Still he said, "We have our own service rigs to look after our own production, and we do a little outside service work."

Another major problem for independents, said Pitcock, "is to treat and reuse the large amounts of water that go into frac jobs" in the Barnett shale and other tight formations. He said, "Right now they say you can't reuse that water. To me that is foolishness. A farmer or a rancher is tickled to death to sell water to us. I was buying water for $300-400 for a well, now we're talking about $2,500-4,000 for drilling water to drill a well." ✦

"After strong cost increases in 2005-06, independents generally expected more muted drilling costs in 2007. Many think drilling costs may have plateaued late in 2007, even at a relatively high rate."

—Pat French, senior vice-president, Texas Alliance of Energy Producers

Bush touts similar energy message in SOTU speech

Nick Snow
Washington Editor

US President George W. Bush commended Congress for passing legislation in 2007 aimed at reducing US dependence on oil and urged federal lawmakers to continue such efforts in 2008 during his seventh State of the Union address.

"To build a future of energy security, we must trust in the creative genius of American researchers and entrepreneurs and empower them to pioneer a new generation of clean energy technology. Our security, our prosperity, and our environment all require reducing our dependence on oil," he said in his Jan. 28 speech to lawmakers, government officials, and guests in the US House chamber. "Last year, I asked you to pass legislation to reduce oil consumption over the next decade and you responded. Together, we should take the next steps," Bush said.

He urged them to fund new technologies to generate power from coal while capturing carbon emissions, to increase use of electricity from renewable sources and "emissions-free nuclear power," and to continue investing in advanced battery technology and renewable fuels to run motor vehicles in the future.

Bush also asked the 110th Congress to help create a new international clean technology fund to help China, India, and other developing nations get more of their energy from clean sources. "And let us complete an international agreement that has the potential to slow, stop, and eventually reverse the growth of greenhouse gases. This agreement will be effective only if includes commitments by every major economy and gives no one a free ride," he said.

"The United State is committed to strengthening our energy security and confronting global climate change. The best way to meet these goals is for America to continue leading the way toward the development of cleaner and more energy-efficient technology," the president maintained.

'No different'

Most congressional reactions concentrated on other parts of Bush's address. Rep. John E. Peterson (R-Pa.) said he was disappointed that the president did not call for the development of more domestic oil and gas supplies. "It's no secret that I have strongly disagreed with this administration's policy of keeping our abundant natural resources under lock-and-key. Tonight's address from the president was, unfortunately, no different than his venerable position of 'ask the Saudis and [the Organization of Petroleum Exporting Countries] for more, and nominally encourage conservation,'" he said, following the speech.

Peterson said, while he strongly believes the US should invest in alternative and renewable forms of energy, increasing domestic supplies from traditional sources also is part of the answer to the current energy crisis. "As our chief foreign competitors, namely India and China, are purchasing energy that we've traditionally had access to—not to mention [increasing] their own domestic production—America wrongly continues to rely on unfriendly and often unstable countries for its energy supply," he said.

DOE study sees high North Slope potential

US oil reserves could more than double by 2050 if commodity prices remain high and leasing restrictions ease on Alsaka's North Slope, according to a federal government study.

A detailed assessment of the North Slope by the Department of Energy's Office of Fossil Energy says exploration and development might add 28 billion bbl of economically recoverable oil and 125 tcf of gas during 2015-50. Reserves for all of the US now are 21 billion bbl of oil and 211 tcf of gas.

The forecast assumes continued high oil and gas prices, stable fiscal policies, and access by the producing industry to all areas of the North Slope. Congress has not approved oil and gas leasing of the promising coastal plain of the Arctic National Wildlife Refuge.

During 2005-15, exploration of currently accessible areas will add about 2.9 billion bbl of oil and 12 tcf of gas, the study predicts.

Total reserves additions for the whole study period, including reserves growth in known fields, could reach 35-36 billion bbl of oil and 137 tcf of gas under the least restrictive set of assumptions, the study says.

"For this optimistic scenario, the productive life of the Alaskan North Slope would be extended well beyond 2050 and could potentially result in the need to refurbish [the Trans-Alaska Pipeline System] and add capacity to the gas pipeline," the study says. A pipeline for North Slope gas production is not yet in place.

The forecast reserves additions decline with changes of key assumptions:

- To 29-30 billion bbl of oil and 135 tcf of gas if the ANWR coastal plain is removed from consideration.
- To 19-20 billion bbl of oil and 85 tcf of gas if the Chukchi Sea Outer Continental Shelf also is removed.
- To 15-16 billion bbl of oil and 65 tcf of gas if the Beaufort Sea OCS is added to the removal list.
- To 9-10 billion bbl of oil if all those areas are removed and no gas pipeline is built.

"This was the president's final opportunity to declare to the American people that we should finally break our shackles from foreign nations and move toward energy security by opening up the Outer Continental Shelf for energy production. Sadly, though, the president did not use the evening's occasion to demonstrate leadership on energy security," Peterson said.

"Opening up the OCS would create American jobs and drive down the cost of energy for our manufacturers, our churches and hospitals, and folks living on fixed incomes. While Washington politicians continue to promise and subsidize 'green-collar' jobs, it is my fear that if we do not address our energy crisis sooner or later, blue-collar jobs in America will be few and far between," Peterson said.

IPAA reaction

The Independent Petroleum Association of America released a statement in response to the president's address. IPAA Pres. and Chief Executive Officer Barry Russell said, "President Bush was right to again raise the energy issue in his State of the Union address. Energy costs, security, efficiency, and reserves are among the most importance issues facing America and the economy. A solid energy policy that increases American oil and gas production is essential to helping the economy by keeping more petrodollars at work in the US."

Russell said, "In addition to the Bush Administration's proposals to allow oil exploration in some areas of the Arctic National Wildlife Refuge, we should also open access to natural gas supplies in the mountain states and allow increased exploration and production in the Outer Continental Shelf, where we are known to have decades of oil and gas supplies.

"Our best defense against foreign oil dependency is developing the vast oil and natural gas resources we have here in America. This energy is our true strategic petroleum reserve, and government policies should encourage its development. The majority of these critical resources, however, remain off limits. Nearly 85% of the nation's offshore resources are restricted by the government for exploration, which if developed could replace Persian Gulf imports for the next 59 years. As if this was not enough, clean natural gas in the Intermountain West that is currently off-limits in nonpark, nonwilderness government lands could heat 50 million US homes for the next 60 years," Russell said.

Other signals

While other parts of Bush's address did not specifically mention energy, some signaled how he would respond to legislation that could affect the business. He promised to veto any bill that would increase taxes, for example, a po-

sition that led to the elimination of oil and gas taxes that Congress had inserted into the energy bill and that eventually became law in December.

Bush also said he would submit a proposed budget for fiscal year 2009 that would terminate or substantially reduce "151 wasteful or bloated programs, totaling more than $18 billion." Bush said, "The budget that I'll submit will keep America on track for a surplus in 2012. American families have to balance their budgets. So should their government."

While the primary focus in Washington will be on passage and adoption of an economic stimulus package, energy-related activities also are scheduled. US Sec. of Energy Samuel W. Bodman was scheduled to deliver the keynote address at a global biofuels conference of the US Chamber of Commerce on Jan. 29. The Senate Energy and Natural Resources Committee planned a hearing on carbon capture, sequestration, and transportation on Jan. 31. At the same time, the Senate Environment and Public Works Committee planned a hearing on recommendations by the National Surface Transportation and Revenue Study Commission that includes substantially increasing gasoline taxes.

In a joint statement following the President's address on Jan. 28, House Speaker Nancy Pelosi (D-Calif.) and Senate Majority Leader Harry M. Reid (D-Nev.) said in a joint statement they hoped the bipartisanship that was shown in preparing an economic stimulus package in the past week was a sign of things to come. "But the president must do more than simply give speeches that promise progress and commit to cooperation. He must work with Congress to make it happen," they said.

"If the president holds fast to the commitment he made to bipartisanship tonight, we can make great progress for the American people this year," Pelosi and Reid said. ✦

API: US natural gas drilling breaks record in 2007

Nick Snow
Washington Editor

US oil and gas exploration and production activity remained robust during 2007 as producers drilled a record number of natural gas wells, the American Petroleum Institute said.

Oil well completion activity was the most active since 1990, while total estimated footage was the highest in two decades, API said Jan. 24 in its latest quarterly well completion report.

An estimated 52,731 oil wells, gas wells, and dry holes were completed domestically in 2007, according to API.

WATCHING GOVERNMENT

Nick Snow, Washington Editor

Greenhouse gas control issues

US Senate Environment and Public Works Committee Chairwoman Barbara Boxer (D-Calif.) did not hide her displeasure as she opened a Jan. 24 hearing on Environmental Protection Agency Administrator Stephen L. Johnson's refusal to grant California and 14 other states authority to impose tougher greenhouse gas controls on motor vehicles.

"In my many years in the House and in the Senate, I have never seen such disregard by an agency head for Congress and for the committee with responsibility for oversight of his agency," she said. Four more states are moving toward adopting California's standards, Boxer said. Johnson, in a prepared statement, said the federal agency had granted California several previous waivers that involved pollutants affecting local and regional air quality. GHGs are "fundamentally global in nature," he said.

Congress considered amendments to Title II of the Clean Air Act in the fall of 2007 concerning GHG emissions regulations with respect to both vehicles and fuels, but it did not make the proposals part of the energy bill it passed on Dec. 18 and that US President George W. Bush signed into law a day later, Johnson said.

'Common sense'

The energy bill did substantially strengthen fuel economy standards for cars and light-duty trucks nationwide, an approach that Johnson prefers in this case. "I just think it is common sense," he said.

Three governors who testified—Maryland's Martin O'Malley, Vermont's Jim Douglas, and Pennsylvania's Edward Rendell—opposed Johnson's decision. But Douglas Halland, member services director in the California Assembly's Republican Caucus, called it "a reasoned response to a process that has been allowed to spin out of control in California."

The US became a signatory nation to the 1997 Kyoto Protocols in 1998 but there has been no action to ratify the treaty since then, much to the distress of several national environmental organizations, Halland said.

Environmental 'bank-shot'

Halland testified, "These groups have taken their message to states and municipalities urging 'local' action since Washington has not committed us to the requirements of the protocols. As a result, California has become the 'bank-shot' around Washington's perceived inability to take action." Michigan Atty. Gen. Mike Cox conceded that there are instances where federal laws shouldn't preempt more aggressive state regulation. But he added that global climate change can't be solved by focusing on automobiles, a single source of less than a third of US GHGs and 7% of such emissions worldwide.

The proposed waiver also doesn't analyze potential costs, Cox said. "Allowing California and the other states that adopt its regulations to impose what would become the de facto national standard contravenes principles of federalism and undermines the possibility for our nation to speak and act with one voice in addressing this global problem."

Boxer disagreed. Following the hearing, she and 17 cosponsors introduced a bill to overturn Johnson's decision. ✦

The fourth quarter's estimated 13,737 completions were the highest since 1986's first quarter, it added.

Natural gas continued to dominate as an estimated 30,625 wells were drilled during the year, with 7,785 of them sunk during the fourth quarter. US gas drilling reached a quarterly peak during 2007's final quarter, API noted.

A resurgence in oil well completion activity, which began in 2000, continued in 2007 as an estimated 17,223 wells were drilled, API reported. Exploratory gas well estimates rose for a fifth consecutive year to a record 3,613, while the estimated 981 exploratory oil well total was comparable to 1986, the report said.

Total footage for the year, which API said was the highest in two decades, was about 306,424,000 ft, with 77,812,000 ft drilled during the fourth quarter, it indicated.

Oil's share grew

The report was similar to others which showed gas continuing to be the primary driving force in domestic exploration and production. But there also were signs that oil's share of total activity grew during the year.

The total number of rigs working in the US during 2007 averaged 1,768/week, according to Baker Hughes Inc. Gas accounted for more than 80% of the total through the year, but oil's share grew from 16% during January, or an average 269.5 wells/week, to 19% during December, or an average 337.5 wells/week. Gas drilling grew more modestly from an average 1,440.25 wells/week during January to 1,468 wells/week during December.

Prices may be having an influence. Oil prices pushed to near $100/bbl in early January, driven by: the Organization of Petroleum Exporting Countries' decision to maintain current production; geopolitical issues in Iran, Nigeria, and Pakistan; and by a sharp decline in US inventories, the Federal Reserve Bank of Dallas said in its January 2008 Houston Economic Update.

Meanwhile natural gas prices

remained in the $7-8/Mcf range as they felt downward pressure from moderate winter weather and inventories that are about 10% above normal for mid-winter. They were supported, however, by sharply rising oil prices, the Dallas Fed said.

"Domestic drilling held steady near 1,800 working rigs [during 2007], but the Texas rig count jumped sharply, once again led by work in the Barnett shale near Fort Worth. Expectations are for drilling to decline in Canada in 2008 and remain steady or pick up in the US and for lucrative international work to continue to grow," it indicated.

It said that pricing for drilling and other oil field services remains mixed, depending on the line of business, on domestic weakness versus international strength, and on declines in pricing for some drilling durable goods vs. better pricing for some nondurable products. "Overall, price pressures in oil services have eased significantly since last spring," the Dallas Fed report noted. ✦

OWA: W. Africa is strategic for global crude oil supplies

Uchenna Izundu
International Editor

Offshore West Africa is poised to become an important source of oil and gas supplies for global consumption, with 6.5 billion bbl of oil discovered in the last 2 years alone.

Speaking at the Offshore West Africa conference in Abuja, IHS Energy analyst Adebola Adejumo said oil companies were attracted to the province because of large discoveries and rising energy prices.

"Angola, Algeria, Libya, and Nigeria will provide 80% of the production," Adejumo said.

Chris Ogiemwonyi, Nigeria National Petroleum Corp. group executive director of exploration and production, said Brazil's large oil find, Tupi, was an exciting development because it suggested that similar discoveries could emerge off West Africa, as they share similar basins. "We need an aggressive exploration program," he added.

With fears intensifying over the volume of the world's produced reserves and a reduction in access to prolific oil and gas zones such as Russia and Iran, oil companies are turning to West Africa as they rework mature producing areas.

The world holds an estimated 4.82 trillion bbl of oil resources with only 1.08 trillion bbl produced.

But the challenges to bring on production—particularly in deep water—are immense, speakers noted during the opening session. Operators are finding tightening fiscal regimes in applying for licenses, increasing project costs, and

OWA: Pressure increases to bring peace to Niger Delta

Uchenna Izundu
International Editor

Funds of $4 billion allocated by the Nigerian government to the Niger Delta for its development over the last 4-5 years have been swallowed up by increased governmental staff wages, security, and corruption, a senior official said.

Speaking at the Offshore West Africa conference, E. Utuama, deputy governor for Delta State, said staff numbers in government posts had risen because there weren't any jobs in the private sector. "Everyone is looking for a job," Utuama said.

But Nigeria should form an Inspector General's office to monitor sustainable development projects in the Niger Delta and help quell the unrest that is blocking oil and gas production, said Stephen Benstowe, a Niger Delta community relations advisor, at the conference session looking at sustainable development in that area.

Timely release of funds for development in the Niger Delta was critical, said Benstowe, who also has provided advice to the Bonny Island community that hosts the Nigeria LNG plant. The problems in the region can be blamed on government inaction and insincerity from oil companies with their sustainable development policies, Benstowe said. Operators are failing to integrate and engage with the communities. "Who is responsible for sustainable development in Nigeria? It has earned $20 billion/year over the last 4 years from oil, and there are 20 million inhabitants in the Niger Delta who live in abject poverty and are grossly neglected."

The government has formulated the Niger Delta Master Plan to reduce poverty, diversify the economy, improve health and develop new transport, communications, and waste management facilities. So far, militants and residents from the region have complained bitterly about its poor implementation.

Community Development Foundations, where communities and oil companies work together to address their needs, have had some success, said Anthony Bolarin, general manager of sustainable development at Elf Petroleum Nigeria Ltd. "There have been lots of national development plans proposed before, and if we're not careful there will be another one. Things have started to be built, but haven't finished or those that have finished have been grassed up."

Bolarin said global memorandums of understanding have been a failure in spearheading development in the Niger Delta. "We need to let the community come back to the center and ask them what they want. We must stop dictating to them," he said.

political volatility, which must be surpassed to unlock the region's potential.

Oliver Onyewuenyi, program manager for global deepwater R&D at Shell International Exploration & Production, said the cost of drilling deepwater wells has risen from $30 million to $100 million. Developing new technologies is crucial to tapping deepwater oil and gas fields where there is rugged terrain, shallow gas seepage, and a low seabed temperature environment. "Subsalt imaging is evolving to help us do more," he added.

Other technologies that are enabling deepwater exploration and production include subsea processing and long-distance subsea tiebacks.

However, associated gas in Nigeria and Angola is a key problem for operators in developing major projects, Onywuenyi said. "How do we monetize it? If you can convert the gas to LNG or liquids, then that can help the economics of projects."

Nigeria's gas flaring has amounted to $32 billion/year, according to Adejumo. This is equivalent to 3.5 billion boe over the past 26 years. It has repeatedly extended its zero gas flaring deadline, but Adejumo said Nigeria was unlikely to meet it unless local consumption could be stimulated and pipelines built to gather gas. Major international projects such as the West African gas pipeline, Trans Sahara gas pipeline and additional liquefaction trains at Nigeria LNG will use associated gas that otherwise would be flared.

Nigeria's Petroleum Minister H. Odein Ajumogbia indicated that the new zero gas flaring deadline could be yearend. ✦

Nigeria expects OPEC production to remain level

Uchenna Izundu
International Editor

Nigeria does not expect to see a change in oil output from members of the Organization of Petroleum Exporting Countries at the group's upcoming emergency meeting being held Feb. 1 in Vienna, a senior oil official said.

H. Odein Ajumogbia, Nigeria's minister of petroleum, attributed the volatile high oil prices to "speculation on geopolitical factors," stressing that price was not underpinned by the fundamentals of supply and demand. "There is no need to suggest intervention, and we have been looking to see if there is a trend in the price, but it has gone up and down."

Very high oil prices could eventually backfire by dampening global demand, Ajumogbia added, particularly in the US, which in turn, could affect China and India. "It is a difficult question to

answer on [which] moves OPEC will make this year," he said.

Nigeria plans to increase its oil reserves to 40 billion bbl by 2011 and to increase production to 4 million b/d by the same date, although that would mean an increase in its OPEC production quota.

The minister confirmed that Nigeria wants to invest $30 billion or more over the next 4-5 years in the upstream sector, with the money coming from both domestic and external financing.

In 2008, Ajumogbia said, Nigeria is looking for $3.9 billion from capital markets, banks, and partners. "It is clear that the more we invest, the more we will get back," he said.

He told OGJ that Nigeria missed its zero natural gas flaring target Jan. 1. It will now impose "fair but reasonable" penalties on operators that continue to flare gas. He said the president may set a new target, possibly yearend 2008. "We are determined to eliminate gas flaring," Ajumogbia said.

The penalty aims to compensate for wasting the resources, he said, but it won't dissuade operators from producing gas.

Reforms of Nigeria's National Petroleum Co. are on course, he added. NNPC will be split into units to make it more productive and effective in a global energy market (OGJ Online, Sept. 10, 2007). "The power and gas committees will write their reports by the end of February so that they can meet the president's 6-month deadline." ✦

New consortium formed to manage Kashagan field

Eric Watkins
Senior Correspondent

A new managerial consortium consisting of Eni SPA, Royal Dutch Shell PLC, Total SA, and ExxonMobil Corp. has been formed to perform operational management of Kazakhstan's Kashagan oil field, said Eni Chief Executive Officer Paolo Scaroni. He said Eni will continue to manage the test phase.

In a conference call with financial analysts, Scaroni explained details of the deal Eni reached with the Kazakh government (OGJ Online, Jan. 18, 2008).

According to a report in Milan's Il Giornale newspaper, the consortium will have priority in negotiations on extending the contract for the exploitation of Kazakh oil field beyond the allotted time frame.

The consortium also will have the right to match any proposals put forward by other companies negotiating any further exploitation of the project.

Scaroni pointed out that the "lengthy negotiations have delayed the first barrels being produced from the oil field. Now, this will take place in 2011, and the production will be 370,000 b/d."

Stefano Cao, director general of Eni's exploration and production division, said the exact amount of investment to be made in the project will not be known until March.

"We have to see what the outcome of the claim will be and then we will do our sums; a few months will be required to draft the budget and the experimental plan," Cao said.

The manager then dealt with the amount of compensation that the government claims is $5 billion, but other estimates suggest $2.5-4.5 billion.

"The compensation will be the outcome of mechanisms established in the contract: a bonus, a priority payment, and a change in the interest rates that will be applied to the investment and that are linked to oil prices," he said.

"The combination of these three factors will result in a different transfer value, which will be based on the scenario we face. Anyway, the priority payment will start after the beginning of production, as will the mechanism to calculate the interest," Cao said.

According to Scaroni, Il Giornale reported, "The bonus relates to a small sum in comparison with the compensation value as a whole, the bulk of which is connected to events within the oil and gas industry." ✦

Bush asked to recall US-Cuba boundary note

Nick Snow
Washington Editor

US Sen. Bill Nelson (D-Fla.) has asked President George W. Bush to recall a diplomatic note to Cuba delineating Gulf of Mexico boundaries because of a Jan. 15 agreement between Brazil and Cuba's national oil companies.

The agreement between Petroleo Brasileiro SA (Petrobras) and Cuba's Cupet "foresees assessment of the offshore blocks in the Cuban sector" of the gulf, Petrobras said. It also provides for technical and economic analyses for construction of a lubricants factory in Havana as well as provisions concerning refining, maintenance, research and development, and human resources, Petrobras said.

"I am alarmed by new reports that Brazil and Cuba have agreed to jointly explore for oil off the island's northwest shores. Two years ago, Spain and wildcatters from Canada signed agreements with [Cuban leader] Fidel Castro to explore his country's offshore oil deposits. And both India and China have expressed their intention of explore there as well," Nelson said to Bush in a Jan. 23 letter.

Activity in Cuban waters could place oil rigs within 50 miles of the Florida Keys and a marine sanctuary there, Nelson warned. "And, as the Gulf Stream flows, an oil spill or other drilling ac-

WATCHING THE WORLD

Eric Watkins, Senior Correspondent

Egypt's rising energy stature

Egypt's increasingly strategic role in oil and gas shipping, as well as nuclear and alternative energy, was recently highlighted by US Sec. of Energy Samuel W. Bodman on his tour of the Middle East.

"Egypt has long been a key energy ally of the United States, and we are committed to continuing and expanding the strategic partnership between our two nations," Bodman said.

One does not often read of the "strategic partnership" between Egypt and the US. In fact, few people I know have ever even heard of it. But that does not mean the secretary is making things up.

In fact, Egypt really is going to have an increasingly important role in US energy security due to growing concerns about Iran and its ability to interrupt shipping through the Straits of Hormuz.

Alternative routes

If that were to happen, then alternative routes would have to be available immediately to ensure the continued flow of oil supplies to the US and its allies. One of those alternative routes, of course, is through the Suez Canal.

It was therefore not surprising to learn that Bodman also spoke with Chairman of the Suez Canal Authority Adm. Ahmed Ali Fadel to discuss Egypt's recent announcement of increased transit fees as well as the canal's importance to energy security.

In case you missed it, Fadel announced in December that transit fees would rise by an average of 7% from April 2008 but by 7.4% for crude oil tankers, 7.4% for oil product tankers, and 10.5% for LNG carriers.

At the time, Fadel expected canal revenues to reach $4.6 billion in 2007, the highest ever, and an increase of 20.5% from $3.82 billion in 2006. But Fadel wants to increase traffic through the canal even further.

Luring competition

By contrast with higher fees for oil and gas tankers, charges for container ships are to rise by a mere 5.7%. And that's no accident.

"We want to lure more containers into using the US East Coast ports via Suez," said Fadel. "We will give service with competitive and lower prices."

The authority already is strengthening ties with US East Coast terminals, including the Port of Hampton Roads in Virginia, before the Panama Canal completes a 7-year, $5.2 billion expansion.

With the prospect of delays, strikes, and costs for inland transport rising across the US, the Suez Canal would offer a direct all-water route from the Far East to the US East Coast, said Fadel, who formerly commanded the Egyptian navy.

While such traffic might fatten Egypt's coffers, it also means two things for the oil industry: ever higher prices to transit the canal due to competition and the prospect of increased collisions due to the higher numbers of ships that will be using it.

No wonder Bodman wanted to chat energy security with Fadel. ✦

cident would desecrate part of Florida's unique environment and devastate its $50 billion tourism-driven economy," he said.

Nelson said that Cuban waters, as delineated by the US-Cuba 1977 Maritime Agreement, are just 45 miles off southern Florida's coast. The agreement was never ratified by the US Senate, but has been enforced by the exchange of diplomatic notes every 2 years, he said.

"My staff informs me the State Department has sent the latest such notes, but that they have not yet been received by the Cuban government. So I am writing to ask you to recall those notes," Nelson's letter said. He said that he looked forward to working with Bush "to ensure that we not only protect Florida, but also prevent the Castro regime from being enriched at our expense." ✦

Brazil makes inroads in Cuba, signs E&P agreements

Eric Watkins
Senior Correspondent

Brazil's state-owned Petroleo Brasileiro SA (Petrobras) has signed agreements with Cuba's Cupet for cooperation in oil and gas exploration and production, research and development, and human resource cooperation. Studies also will be undertaken for agreements concerning facilities maintenance.

The agreements give Brazil a foot in Cuba's energy door that Venezuela has, until recently, partially blocked.

Petrobras, which has expertise in deepwater exploration and production, said the agreement "foresees the assessment of the offshore blocks in the Cuban sector of the Gulf of Mexico, as well as technical and economic analyses for the construction of a lubricant factory in Havana."

Cuba hopes its exploration in the

deepwater Gulf of Mexico will result in discoveries enabling the country to become self-sufficient in oil production. The US Geological Survey says Cuba's GOM areas could contain 4.6-9.3 billion bbl of crude and 9.8-21.8 tcf of gas (OGJ, Jan. 21, 2008, p. 41).

Brazil also extended Brazilian credit to Cuba for food, medicine, and hotel and road construction.

Brazil's official Agencia Estado news agency said the agreements coincide with political transition in Cuba a year and a half after Cuban President Fidel Castro transferred power to his brother Raul due to health problems.

Agencia Estado said the aid program has a long-term strategy: Brazil sees Cuba as a growing market and a transshipment point in a "privileged location" near Florida, and it wants to be in a positive position "when trade opens up as part of Fidel's succession process."

Venezuela-Cuban pacts

Venezuela is Cuba's biggest trading partner in South America, and Brazil wants to recover ground lost to Hugo Chavez. Since 2003, Chavez has been selling petroleum to Cuba at subsidized prices in exchange for the island's sending physicians, nurses, and hospital equipment to Venezuela.

"It was because of Venezuela that Cuba's negotiations with Petrobras in the past reached an impasse," said Agencia Estado.

On Dec. 22, 2007, Chavez and Raul Castro signed 14 energy agreements in Havana, including a $122 million loan for Cuba to buy tankers to transport crude oil and products from Venezuela.

Plans also call for Venezuela and Cuba jointly to increase the capacity of Cuba's 65,000 b/d Cienfuegos refinery to 150,000 b/d. Built in 1990 with Soviet technology and mothballed in 1991, the refinery reopened Dec. 21, 2007, following Venezuela's renovations. Cuba also will reopen an oil pipeline from the refinery to Matanzas.

Cuba has endured a 50-year US economic embargo that precludes US firms from investing in such projects. ✦

Outlook for US gas supply improves if production efforts are stepped up

Henry R. Linden
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Chicago

This is an update of a recent article by the author in which he painted a rather pessimistic picture of the future of US natural gas production based on the Potential Gas Committee's Dec. 31, 2004, report.[1]

The new total remaining dry gas resource volume of 1,320,950 tcf on Dec. 31, 2006, estimated by the PGC[2] represents an increase of 201.695 tcf from the Dec. 31, 2004, value in spite of a decrease in the coalbed methane value.[2] To the end-2004 resource must be added the end-2004 proved reserves of 192.513 tcf.

As noted on Table 1, the PGC in its end-2006 estimate of remaining US dry gas reserves and resources of 1,525 tcf used an obsolete end-2005 value of 204 tcf for its estimate of total remaining dry US gas supplies (actually 204.385 tcf) instead of the end-2006 value of 211.085 tcf (Lower 48 states 200.840 tcf plus 10.245 tcf in Alaska.[3]) Thus, the corrected end-2006 value of potential US gas resources and proved reserves is 1,532.035 tcf.

Future US production

In order to arrive at an estimate of how much US gas remains for future production, cumulative production through the end of 2006 must be added.

In its Dec. 31, 2006, report, the PGC estimated this value at 1,091 tcf on Table 5, p. 8,[4] or a total original resource base using the corrected value for end-2006 proved reserves of 2,623 tcf.

Assuming that total US dry gas production follows an symmetrical inverted bell-shaped (sigmoidal) curve as originally proposed by the eminent geologist M. King Hubbert—who correctly projected US peak crude oil production by this method[1]—the peak in total US dry gas production would occur when one-half, or 1,311.5 tcf, have been recovered.

Subtracting the 1,091 tcf already produced leaves only about 221 tcf before production would plateau.

At projected dry gas production levels of 19.35 tcf in 2010 and 19.60 tcf in 2015[5] we would have 11.3 years of slightly rising production levels remaining unless an all-out effort is made to tap what are believed to be vast remaining conventional and unconventional (tight formations, Devonian shales, and coalbed methane) resources.

The latter seems likely as discussed below. This does not even include the potentially enormous resource of more than 100,000 tcf of methane locked in hydrates in nine

US ESTIMATED POTENTIAL DRY GAS RESOURCES, PROVED RESERVES AS OF DEC. 31, 2006*

Table 1

Traditional resources	Probable	Possible	Speculative	Total
	Mean values, tcf			
Resources (Potential Gas Committee)				
Lower 48				
Onshore	216.760	330.926	263.756	812.799
Offshore	16.492	53.870	83.919	154.279
Subtotal	233.248	384.823	347.906	965.618
Alaska				
Onshore	31.717	22.300	40.417	94.432
Offshore	5.142	19.499	74.788	99.366
Subtotal	36.856	41.816	115.129	193.831
Total traditional	270.100	426.408	460.740	1,154.809
Coalbed gas resources	15.514	50.899	98.935	166.141
Total potential US	285.614	477.307	559.675	1,320.950
Proved reserves (Energy Information Administration)				
Lower 48				200.840
Alaska				10.245
Total proved reserves				211.085
Total remaining US dry natural gas reserves and resources				1,532.035

*The total US (including Alaska) proved reserves used by the Potential Gas Committee are 204 tcf (actually 204,395 tcf) on 12/31/05, not the proved dry natural gas reserves of 211,005 tcf on 12/31/06 from Reference 3.
Sources: "Potential Supply of Natural Gas in the United States," Report of the Potential Gas Committee (Dec. 31, 2006), Potential Gas Agency, Colorado School of Mines, November 2007, Table 1, p. 5. "Advance Summary, US Crude Oil, Natural Gas and Natural Gas Liquids Reserves," 2006 Annual Report, Energy Information Administration, Office of Oil and Gas, US Department of Energy, October 2007, Document No. DOE/EIA-0216 (2006) Advance Summary

NATURAL GAS EXPLORATION, DEVELOPMENT, PRODUCTION, AND RESERVE REPLACEMENT

Table 2

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Active rig count	427	385	464	564	560	496	720	939	691	872	1025	1,184	1,372
Gas well completions	9,538	8,454	9,539	11,186	11,127	11,121	16,242	21,403	16,728	19,522	21,816	27,014	31,587
Gas wells/rig	22.3	22.0	20.6	19.8	19.9	22.4	22.6	22.8	24.2	22.4	21.3	22.8	23.0
Total discoveries	12.3	11.0	12.3	15.6	11.4	10.8	19.1	22.8	17.8	19.3	20.2	23.2	23.3
Net revisions and adjustments	7.4	8.3	7.9	4.3	4.1	11.5	6.1	0.4	4.7	1.2	0.6	4.6	–1.1
Net of sales and acquisitions	—	—	—	—	—	—	4.0	2.6	0.4	1.0	1.8	2.5	3.0
Total additions, tcf	19.7	19.3	20.2	19.9	15.5	22.3	25.2 *29.2	23.2 *25.8	22.5 *22.9	20.5 *21.5	20.8 *22.6	27.8 *30.3	22.2 *25.2
Additions/well, bcf	2.1	2.3	2.1	1.8	1.4	2.0	1.6 *1.8	1.1 *1.2	1.3 *1.4	1.1 *1.1	1.0 *1.0	— —	— —
Dry gas production, tcf	18.3	18.0	18.9	19.2	18.7	18.9	19.2	19.8	19.4	19.4	19.2	18.5	18.5
Reserve replacement, %	108	107	107	104	83	118	131 *152	117 *131	116 *118	106 *111	108 *118	150 *163	120 *136

*These higher values are obtained if a new category "net of sales and acquisitions" is added to "total additions."
Sources: Monthly Energy Review, October 2007, Table 5.1, "Crude Oil and Natural Gas Drilling Activity Measurements" and Table 5.2 "Crude Oil and Natural Gas Exploratory and Development Wells," Energy Information Administration, Office of Energy Markets and End Use, US Department of Energy, Document No. DOE/EIA-0035 (2007/10).

US coastal plays and one small Arctic onshore play in Alaska.

Worldwide needs

In view of the importance of gas with an carbon to hydrogen atomic ratio of 1:4 compared with 1:2 for oil, 2:1 for coal, and 10:1 for wood as the obvious transition fuel to a carbon-free US and global energy system and the encouraging 2007 report by the PGC, a stepped-up US and global effort to increase gas production is clearly indicated.

This requires first of all more US and international pipeline capacity, notably from Alaska to the Lower 48 states, more Russian Gazprom pipelines to Europe and a new pipeline to China, and a continued increase in liquefied natural gas production, tanker transport, and receiving and gasification facilities in the US, Europe, India, and China.

In addition, it calls for a serious effort to develop the methane hydrate option globally to recover a significant portion of the roughly 700,000 tcf of methane locked largely in coastal deposits and in terrestrial deposits in subarctic regions such as Siberia.[6]

In Table 2, the encouraging data of US reserve replacement from 1994 through 2006 are summarized. It is an update of Table 6, Parts 1 and 2, in a recent article by the author[7] and shows the US exploration and production industry's remarkable ability to more than replace dry gas production with reserve additions.

From 1994 through 2006, only in 1998 was the value below 100% (83%). In all other years, reserve replacement exceeded gas production by as much as 131% to 163% (2005). In connection with the encouraging 2005-06 PGC biannual report summarized in Table 1, this offers great promise that the US will be able to meet its consumption needs for at least 11 years as noted above, although that is not nearly enough if current US power generation by inefficient (about 30-35%) coal-fired steam-electric plants were to be replaced by efficient (60%) gas-fired combined cycle plants to reduce carbon dioxide emissions by two-thirds as discussed in detail in Reference 7.

It therefore seems imperative to develop and commercialize Integrated Coal Gasification-Combined Cycle (IGCC) plants modified with a catalytic water gas shift step with more steam ($CO + H_2O \rightarrow CO_2 + H_2$) of the raw synthesis gas and removal and sequestration of the CO_2 in suitable underground formations to produce a more than 90% pure hydrogen stream for efficient combined-cycle power genera-

NATURAL GAS SUPPLY AND DISPOSITION

Table 3

Supply and disposition	Reference case							Annual growth 2005-30, %
	2004	2005	2010	2015	2020	2025	2030	
	Tcf/year							
Production								
Dry gas[1]	18.76	18.23	19.35	19.60	20.79	20.59	20.53	0.5
Supplemental natural gas[2]	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.1
Net imports	**3.40**	**3.57**	**4.55**	**5.62**	**5.35**	**5.58**	**5.45**	**1.7**
Pipeline[3]	2.81	3.01	2.74	2.63	1.65	1.20	0.92	–4.6
LNG	0.59	0.57	1.81	2.99	3.69	4.38	4.53	8.7
Total supply	**22.22**	**21.87**	**23.97**	**25.29**	**26.21**	**26.24**	**26.06**	**0.7**
Discrepancy[4]	–0.17	–0.11	–0.05	–0.03	–0.05	–0.06	–0.06	N/A

[1]Marketed production (wet) minus extraction losses. [2]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for btu stabilization, and manufactured gas commingled and distributed with natural gas. [3]Includes any natural gas regasified in the Bahamas and transported via pipeline to Florida. [4]Balancing item. Natural gas lost as a result of converting flow data measured at varying temperatures and pressures to a standard temperature and pressure and the merger of different data reporting systems that vary in scope, format, definition, and respondent type. In addition, 2004 and 2005 values include net storage injections.
Source: Reference 8

AN OVERVIEW OF RUSSIA'S GAS SUPPLY CHARACTERISTICS

Table 4

- Russia has an unparalleled reserve base (27% or 1,680.0 tcf of world total of 6,182.7 tcf as of Jan. 1, 2007[Reference 9]). E&P revenues are a major component of the economy.
- Russia is the world's largest gas exporter, and domestic consumption is second highest in the world after the US.
- Gazprom is the major player in the Russian gas industry and is strongly aligned with the Russian government. Gazprom holds Russia's gas reserves, and produces a total volume almost as large as the entire US market.
- Most of Russia's supply has historically come from three giant fields in the Nadim-pur-Taz region (Yamburg, Urengoy, Medvez), but these fields are in decline. To replace these fields, Gazprom will be forced to develop more remote fields on the Yamal Peninsula or in the Barents Sea.
- Gazprom's production target is 20.5-20.8 tcf by 2020 from a level of 19.1 tcf in 2004. Development of these new fields will be highly capital intensive, and it is unclear if Gazprom will be able to attract sufficient capital to fund these projects.
- Gazprom will also try to increase purchase from other Russian companies and from Central Asia.
- Gas exports are exclusively pipeline supplies to the Former Soviet Union and Continental Europe but the first LNG exports will take place when the Sakhalin LNG plant is commissioned, scheduled for 2008. Other planned LNG projects are aimed at the North Atlantic market.
- Leading gas customers include Germany, the Ukraine, Italy, Turkey, Belarus, France, Hungary, Czech Republic, Poland, Austria, Slovakia, Netherlands, and UK. Gazprom controls the export pipeline system and maintains a monopoly on gas exports.
- Gazprom has publicly expressed its disagreement with several aspects of the European Commission's proposed regulations to promote European Union energy market competition.

Source: Pace Global Energy Services, "Russian Gas Supply to Europe," p. 4, July 2007, private communication, November 2007

tion or as a source of hydrogen for fuel cell-powered surface transport.

In Table 3, US gas supply and consumption data (historical for 2003 and 2005 and projections to 2030) published by the Energy Information Administration are summarized.[8] Table 3 shows a peak in dry gas production of 20.79 tcf in 2020, slightly more optimistic than the projection based on the Hubbert methodology discussed earlier.

It can be seen that net pipeline imports and imports will decrease from 3.01 tcf in 2005 to 0.92 in 2030 and that LNG imports will rise only modestly from 0.57 tcf in 2005 to 4.53 tcf in 2030 due to resistance to the construction of new receiving terminals in the US and global competition for supplies. This further increases the urgency of increasing domestic production of gas, including serious pursuit of the methane hydrate option.

The importance of Russia in the global gas supply system is summarized in Table 4 received in a private communication from Pace Global Energy Services in Washington, DC. Russia is the largest gas reserve holder with 1,680 tcf as of Jan. 1, 2006, out of a total of 6,182.7 tcf,[9] or 27%.

Gazprom is the major player in the Russian gas industry and the major source of supply for much of Europe and the countries of the Former Soviet

Union. Of special importance would be the construction of a pipeline to China for power generation to reduce its dependence on coal.

Returning to the prospects of the role of unconventional gas production in US gas supply, there is general agreement that it will provide about 10 tcf from the Lower 48 states to supply a total of roughly 20.5 tcf in 2030.[5] A recent article by Vello A. Kuuskraa et al.[10] makes a detailed analysis of how this volume might be increased.

Nevertheless, it seems increasingly clear that US gas supply, except possibly for LNG imports, will reach a plateau around 2030, unless the positive outlook for increased unconventional gas production is realized.

Outlook

In view of the limitations on US gas supply as a transition fuel to a sustainable energy system which will require 30-50 years, it is clear that we must accelerate the commercialization of the gasification of coal and lignite, the most abundant US and global energy resource, into hydrogen and synthesis gas for the production of synthetic liquid fuels and methane using technologies which permit the removal and sequestration of most of the CO_2 formed.

Sustainable energy systems by definition use inexhaustible and emission-free energy sources such as solar photovoltaic and solar thermal power and wind and hydroelectric power whose availability is limited and which also have some negative environmental impacts.

In addition, the research, development, and demonstration on environmentally benign and economically feasible recovery of methane from the vast US and global resources of methane hydrates must be accelerated. The apparently insurmountable limitations on the use of biofuels as a major sustainable energy source to replace fossil fuels are beyond the scope of this article and have been discussed by the author in two earlier articles and widely in the energy press.[1 11]

Acknowledgment

Thanks are due to the Potential Gas Committee of the Potential Gas Agency, Colorado School of Mines, for making its new Dec. 31, 2006, assessment of potential and proved gas resources and reserves available for this update of future US gas supplies, and to Pace Global Energy Services of its analysis of Gazprom as a source of gas supply for the FSU, much of Europe, and potentially China. ✦

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The author

Henry R. Linden is Max McGraw Professor of Energy and Power Engineering and Management and director of the Energy & Power Center at the Illinois Institute of Technology, Chicago. He has been a member of the IIT faculty since 1954 and was IIT's interim president and CEO in 1989-90, as well as interim chairman and CEO of IIT Research Institute. Linden helped organize the Gas Research Institute (GRI), the US gas industry's cooperative research and development arm that merged with the Institute of Gas Technology (IGT) in 2000 to form Gas Technology Institute. He served as interim GRI president in 1976-77 and became the organization's first elected president in 1977. He retired from the GRI presidency in April 1987 but continued to serve the group as an executive advisor and member of the advisory council. From 1947 until GRI went into full operation in 1978, he served IGT in various management capacities, including 4 years as president and trustee. Linden also served on the boards of five major corporations for extended terms in 1974-98. He worked with Mobil Oil Corp. after receiving a BS in chemical engineering from Georgia Institute of Technology in 1944. He received a master's degree in chemical engineering from the Polytechnic Institute of Brooklyn (now Polytechnic University) in 1947 and a PhD in chemical engineering from IIT in 1952.

Australia

Central Petroleum Ltd., Perth, updated seismic activity on its permits in the Amadeus and Pedirka basins in Australia's Northern Territory.

Terrex Seismic shot 100 line-km of 2D seismic in the Stone Plains prospect area on EP 112 and is preparing lines at the Johnstone prospect in EP 115.

The current 1,150-line-km program is designed to firm up as drill ready prospects the Johnstone, Guinevere, Vivienne, and Madigan oil prospects and the Magee gas-condensate-helium prospect and provide early reconnaissance data over a number of leads. Blamore, Simpson, Waterhouse, Mount Kitty, and Ooraminna are ready to drill, and drillsites have been chosen.

A rig is secured to drill at least two wells, Blamore or Simpson and Mount Kitty, and the contract has options for five conventional wells and three coalbed methane wells.

Quebec

Junex Inc., Montreal, said it conducted the first hydraulic frac job in a shale formation in Quebec in mid-December 2007 at the Becancour-8 well in the St. Lawrence Lowlands.

The well is flowing back natural gas and frac fluids from the Ordovician Utica shale, and it will be several months before final results are known, the company said.

Junex signed an agreement in July 2006 with a large US independent gas producing company for the development of shale gas in the Becancour-Champlain region. That deal targeted the evaluation of gas potential of the shale section on four blocks of permits covering 143,395 acres held by Junex between Quebec City and Montreal.

The partner analyzed 34.15 m of Utica shale core cut from Junex's Becancour-8 well, and based on the results advised Junex that it would proceed with a pilot project, the first step of which was to frac the well.

Kansas

Imperial American Oil Corp., private Wichita independent, gauged an apparent Pennsylvanian Lansing oil discovery on a 3D seismic anomaly in Norton County on the Central Kansas uplift 12 miles west of Norton, Kan.

The Ella Mae 34-1, in 34-2s-24w, several miles from previous Lansing production, recovered 2,740 ft of clean oil and no water on a Lansing C drillstem test. Shut-in pressure was more than 1,165 psi. TD is 3,700 ft.

Such anomalies typically support two to three wells on 40-acre spacing. The company has shot 10 sq miles of seismic and plans to shoot as much as 120,000 in the next few years.

Petrobras continues to add producing facilities off Brazil

Guntis Moritis
Production Editor

Petroleo Brasileiro SA (Petrobras) in 2007 added five floating production units to its extensive operations off Brazil and plans many more during the next decade, according to company reports during the year.

In January 2007, the company started producing to the Cidade do Rio de Janeiro floating production, storage, offloading (FPSO) vessel moored in Espadarte field. In October, production started to the world's first cylinder-shaped FPSO installed in Pirama field.

The FPSO Cidade de Vitoria went on stream in Golfinho field in November. This was followed in November and December with the start-up of the P-52 semisubmersible production unit and the P-54 FPSO in Roncador field

With this additional capacity, production in Brazil set a record of 2 million bo/d near yearend 2007.

As developments in Brazil continue, the company expects production in Brazil to reach 2.421 million bo/d in 2012 and 2,812 million bo/d in 2015 (Fig. 1). Gas production likewise is set to increase to 70.8 million cu m/ day in 2012, up from the 28 million cu m/ day average in 2007 (Fig. 2).

Espadarte

The Cidade do Rio de Janeiro was the second FPSO installed in Espadarte field in the Campos basin. The FPSO has a design processing capacity of 100,000 bo/d and 2.5 million cu m/day of gas.

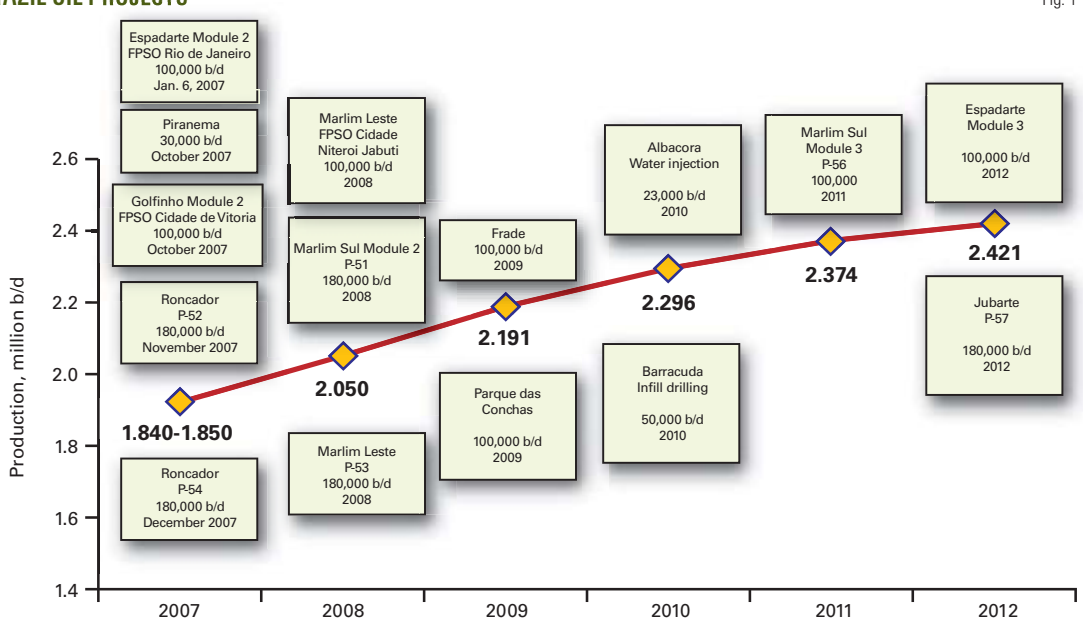
The 320-m long FPSO, moored in 1,350 m of water, provides storage for up to 1.6 million bbl of oil. Petrobras leases the vessel from MODEC International LCC and has tied it into five subsea production wells and four water injection wells.

Petrobras noted that the FPSO has several technological innovations aboard, among which is a new oil-pumping system developed by the Petrobras research center (Cenpes). The underwater centrifuge pumping system (S-BCSS) assists in lifting oil from the field to the platform. It is installed externally to the well, on the seafloor.

Petrobras says that the system will

BRAZIL OIL PROJECTS

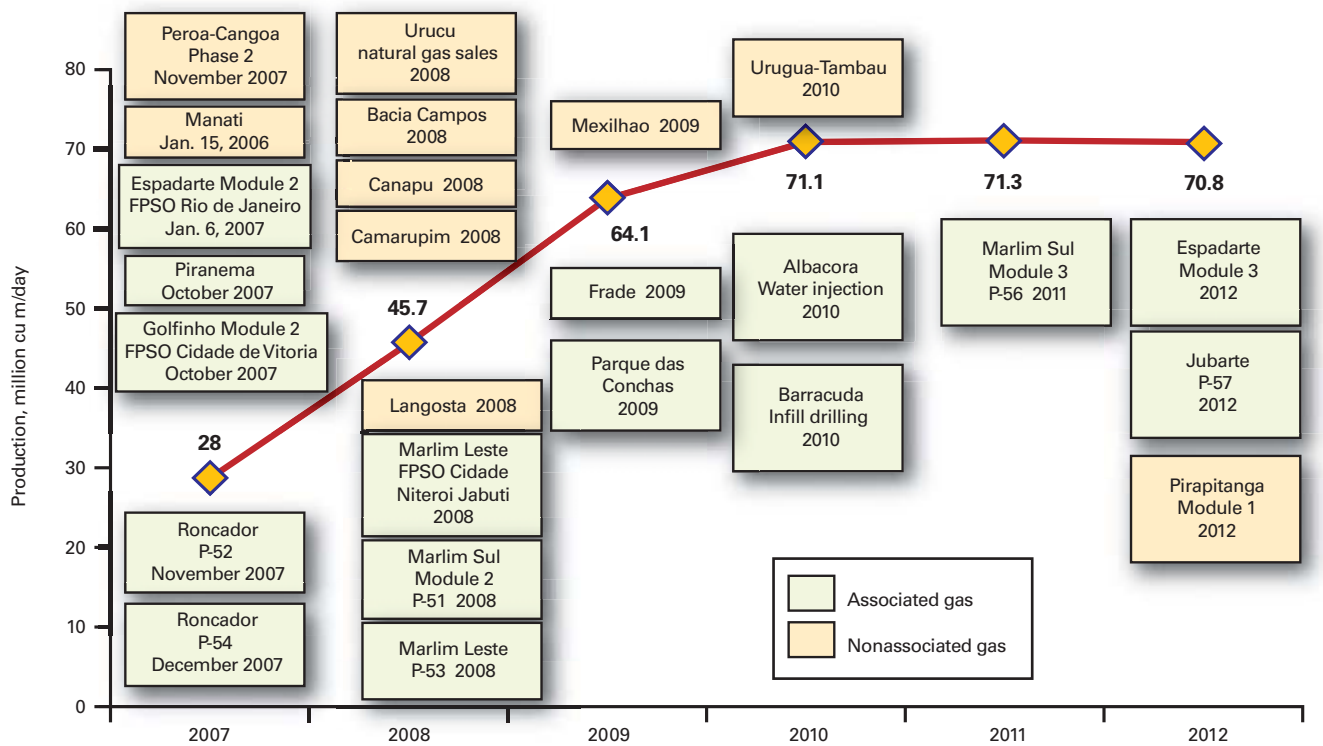
Fig. 1



Source: Based on Barbassa, A., and Castro, C.H.D., Petrobras overview, 9th Foro Latibex, Nov. 22, 2007.

BRAZIL GAS PROJECTS

Fig. 2



Source: Based on Barbassa, A., and Castro, C.H.D., Petrobras overview, 9th Foro Latibex, Nov. 22, 2007.

expedite pump maintenance and facilitate replacement of pumps. This in turn will lower operating costs, facilitate remote intervention in the connected wells, and eliminate the need for completion rigs, one of the most expensive equipment to lease in the international market, according to Petrobras.

Production from Espadarte field, discovered in 1988, started in 2000 to the FPSO Espadarte. The production also includes the eastern part of Marimba field. Petrobras said production to the FPSO Espadarte peaked in 2003 at 45,000 bo/d.

Petrobras installed the world's first cylinder-shaped FPSO in the Pirama field off Brazil (Fig. 3). Photo from Sevan Marine ASA.

Pirama

Petrobras developed Pirama field with a cylindrical FPSO designed to process 30,000 b/d of 44° gravity light oil (Fig. 3). The field is in the Sergipe-Alagoas basin in Northeast Brazil and lies in more than 1,200-1,600 m of water.

Petrobras leases this vessel, the world's first cylinder-shaped FPSO from Sevan Marine ASA. The vessel can store 300,000 bbl of oil and has a 3.6 million cu m/day compression capacity.

Golfinho

The FPSO Cidade de Vitoria, installed

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The P-52 semisubmersible production unit in the Roncador field off Brazil has designed processing capacity of 180,000 bo/d (Fig. 4). Photo from Petrobras.

in the Espirito Santo basin Golfinho field Module 2, has a 100,000 bo/d and 3.5 million cu m/day design processing capacity.

The Golfinho field produces a 28° gravity oil and initial production to the FPSO was 20,000 bo/d from one well with production reaching 70,000 bo/d by yearend after connection of two more wells.

Petrobras expects to reach peak processing capacity in first-half 2008, when production from the Espirito Santo basin, including the previous facilities, may total 200,000 bo/d, up from 120,000 bo/d. Production of Golfinho, discovered in 2003, started with production tests in February 2006 followed by production to the FPSO Capixaba in May 2006.

The FPSO Cidade de Vitoria is in 1,386 m of water, about 50 km off the central portion of the Espirito Santo coast and connects to four oil-producing, two gas-producing, and three water-injection wells.

Oil production is offloaded to tankers, while a pipeline moves the gas ashore to the Cacimbas gas treatment unit in Linhares.

Roncador

Two addition vessels installed in the Campos basin Roncador field started processing production in November and December.

The P-52 (Fig. 4) is a semisubmersible production unit while the P-54 is an FPSO (Fig. 5). With both units online and including the FPSO Brazil installed in 2002, the processing capacity in the field is now 460,000 bo/d.

The P-52 has a designed processing capacity of 180,000 bo/d of 28° gravity oil and can compress 7.5 million cu m/day of gas. The facility has a 300,000 b/d water injection capacity.

Petrobras expects P-52 to reach the designed production capacity in second-half 2008. The vessel is in 1,800 m of water and connects to 18 producing and 11 water-injection wells. P-52 has a 125-m length, 110-m width, and 150-m height including the flare boom.

The Keppel Fels shipyard in Singapore built the hull, while the Brasfels yard in Brazil constructed the topsides and integrated the deck with the hull. Construction lasted 26 months.

The oil processed on P-52 goes to an autonomous repumping platform (PRA-1) and then is transferred to a floating production storage unit (FSO Cidade de Macae), which will also store production from four other future production platforms.

From the FSO Cidade de Macae, Petrobras transfers the oil destined to domestic consumption with offloading tankers to the São Sebastiao terminal, on the coast of Sao Paulo, while export tankers offload and transport the oil elsewhere.

A pipeline transports the gas to a distribution unit and then to the Garoupa platform from which the gas continues ashore. Petrobras expects to reach a 3.2 million cu m/day peak gas flow by yearend 2008.

The other unit added in Roncador was the P-54 FPSO.

Petrobras expects P-54 to reach its 180,000 bo/d design capacity in second-half 2008. At that time the vessel also will be processing about 1.8 million cu m/day of gas.

The vessel has 6 million cu m/day of gas compression capacity.

The P-54 is a conversion of the Barao de Maua tanker and can store 200,000 bbl of oil. As with the P-52, Petrobras says the vessel was built with the new

national content requirement of 63%. Construction took 41 months with the Jurong Shipyard in Singapore converting the hull. The process, utility, and compression modules were built at Maua-Jurong shipyard in Niteroi, Brazil, and the power generation modules at Nuovo Pignone's Porto Novo Rio yard in Caju, Brazil.

Moored in 1,400 m of water, the 337-m long vessel connects to 11 oil and gas producing wells and 6 water-injection wells.

Petrobras expects the P-54 FPSO, installed in Roncador field off Brazil, to reach its 180,000 bo/d design capacity in second-half 2008 (Fig. 5). Photo from Petrobras.

Tankers will offload the oil from the vessel, while a pipeline will move the gas ashore. Petrobras expects a peak gas production of 1.8 million cu m/day.

2008 and beyond

Petrobras plans to deploy three new oil platforms and one gas platform off Brazil in 2008. These include:

- P-51 in Marlim Sul field, Campos basin, with a 180,000 bo/d processing capacity.
- P-53 in Marlim Leste field, Campos basin, with a 180,000 bo/d processing capacity.
- FPSO Cidade de Niteroi in Marlim Leste field, Campos basin, with a 100,000 bo/d capacity.
- FPSO Cidade de Sao Mateus in Camarupim field, Espirito Santo basin, with a designed processing capacity 10 million cu m/day of gas. Petrobras is the operator with 65%, while El Paso holds the remaining 35%.

Figs. 1 and 2 show the offshore facilities planned to be installed off Brazil during 2008-12. In addition, major projects that Petrobras lists as coming on stream off Brazil in 2013-15 include:

- Roncador P-55, Campos basin.
- Papa-Terra, Campos basin, 350 million boe potential. Interest owners are Petrobras 65% and Chevron 35%.
- Maromba, Campos basin, 140 million boe potential. Interest owners are Petrobras 65% and Chevron 35%.
- Cachalote and Balaeia Franca, Campos basin near producing Jubarte field.
- Balaeia Azul, Campos basin near producing Jubarte field.
- Caxareu; Campos basin subsalt discovery at 4,862-m depth, 30° gravity oil, in 1,011 m water depth, and 570 million bbl of in place potential, near Jubarte field.
- Pirambu; Campos basin subsalt discovery, 29° gravity oil, 1,270 m of water.
- Tupi; Santos basin subsalt carbonate discovery, 28° gravity oil, with a potential of 5-8 billion bbl of recoverable oil. Long-term production tests are scheduled for early 2010. Interest owners are Petrobras 65%, BG Group 25%, and Petrogal-Galp Energia 10%. ✦

Design analysis predicts cone behavior

Yuri A. Palashchenko
Consultant
Russia

Drillbit kinematics are defined by the rotation speed and rate of penetration, influenced by the cutting action of the teeth. Each cone of a conventional roller cone bit has several rows of teeth; row placement and tooth pitch may differ for each cone.

Rock drillbit design involves selecting the cone geometry and the shape and layout of the cutting structures. The cone design predetermines the kinematics of the cutting structure and the bottomhole interaction, which subsequently defines the drilling process efficiency and the bit's susceptibility to wear. Peculiarities of cone bit kinematics determine the cone's gear ratio value, which sets the magnitude of the cutting structure skidding when destroying the rock.

Currently, the gear ratio of bit cones is estimated either experimentally by keeping records of the bit and cone RPM while drilling in test stand conditions or by calculations that proceed from the cone geometry.[1] Calculations of cone geometry are initially derived manually (as shown in this series of articles), but current research focuses on dynamic, iterative solutions using complex equations in bit simulations performed by high-powered computing systems.

Experimentally measuring the cone gear ratio may be a matter of interest because its actual value is uncertain at the bit design stage. However, calculating the gear ratio assuming only the cone geometry may not always provide satisfactory results because it does not take into account the formation of the rack on the well bottom due to the rock exposure to the attacking cone teeth. The rack exerts the determining influence upon the character of the rock bit kinematics, the bit performance, and wear.[2]

Therefore, it was necessary to develop a technique to calculate the kinematic parameters of the rock cone bits that would proceed from the real process of formation of the bottomhole rack and the consequent specific features of the cone and bottomhole interaction. Moreover, consideration should be taken of the two possible rock bit modifications: those with equal pitch and varied pitch of the heel teeth for all cones.

CLASSIC BIT KINEMATICS—1

The material will be presented in four articles. This first part discusses classic bit kinematics when the heel teeth have equal pitch on all cones. The second part, to be published next week, will cover bit kinematics when the heel teeth have variable pitch. The third part will cover the formation of the bottomhole rack, and a study of the performance of rock bits interacting with well bottom during pure rolling of the cones. The concluding part provides field data of more than 1,000 m of hole drilled with a single Varel bit in Tatneft OSC oil fields.

Equal pitch, single cone

We begin our analysis of bit kinematics with the condition, $t_1 = t_2 = t_3 = t_c$, in which the pitchs of all the heel teeth of all cones are equal, and $Z_1 = Z_2 = Z_3 = Z_c$, in which the number of the heel teeth in each cone is the same. The pitch value t_c is always known from the relationship in Equation 1 (accompanying box).

Suppose that the impact of the heel teeth rows of all cones per revolution of the bit results in formation of a definite number of craters Z_{cr}. The number of ridges between the craters, Z_{rd}, will be as large as many times the pitch t_c accommodates in the circle circumscribed by the bit with the diameter $D \cdot Z_{cr} = Z_{rd} = Z_r$ where Z_r is the estimated number of the teeth on the bottomhole rack. Equation 2 calculates Z_r. Substituting t_c from Equation 1 yields Equation 3.

Estimated in such a manner, the number of the teeth on the bottomhole rack Z_r may be an integral or a fractional number, as shown in Equation 4.

Naturally, the actual number of the teeth on the bottomhole rack, Z_a, will always be equal to some integral value; this explains the difference in values of the gear ratio for the cones at pure rolling and the actual gear ratio. This difference stipulates an occurrence of the rock bit teeth skidding.

Fig. 1 illustrates the pattern of formation of the peripheral rack on the hole bottom per revolution of the bit,

Equations

$$t_c = \frac{\pi d}{Z_c} \quad (1)$$

$$Z_r = \frac{\pi D}{t_c} \quad (2)$$

$$Z_r = \frac{\pi D}{\pi d} \cdot Z_c = i \cdot Z_c \quad (3)$$

$$Z_r = \frac{\pi D}{\pi d} = i \cdot Z_c = N + \Delta \quad (4)$$

$$S_1 = \frac{\Delta \cdot t}{\sin 60^\circ} = 1.15\Delta \cdot t;\ S_2 = \frac{\Delta \cdot t - t}{\sin 60^\circ} = 1.5(\Delta - 1)t \quad (5)$$

$$S = \delta \text{ and } S_1 = \Delta \cdot t;\ S_2 = (\Delta - 1)t \quad (6)$$

$$z_{r1} = \frac{z_r}{3} = \frac{N + \Delta}{3} = N_1 + \Delta_1 \quad (7)$$

$$S_1' = 3\Delta_1 \cdot t = 3\frac{1 + \Delta}{3} \cdot t = (1 + \Delta) \cdot t \quad (8)$$

$$S_1' = 3 \cdot \frac{2 + \Delta}{3} \cdot t = (2 + \Delta) \cdot t \quad (9)$$

$$S_2' = 3(\Delta_1 - 1) \cdot t = 3\left(\frac{2 + \Delta}{3} - 1\right) = (\Delta - 1) \cdot t \quad (10)$$

$$S_z = \frac{S_1}{3} \text{ or } S_z = \frac{S_2}{3} \quad (11)$$

$$Z_a = Z_r = N \text{ at } \Delta = 0 \text{ (pure rolling)} \quad (12)$$

$$Z_a = Z_r - \Delta = (N + \Delta) - \Delta = N \text{ at } 0 < \Delta \le 0.5 \text{ (slowed - down skidding)} \quad (13)$$

$$Z_a = Z_r - (\Delta - 1) = (N + \Delta) - (\Delta - 1) = N + 1 \text{ at } 0.5 << \Delta < 1 \text{ (accelerated skidding)} \quad (14)$$

$$t' = t + \Delta t = (1 + \Delta) \cdot t \quad (15)$$

$$t'' = \delta \quad (16)$$

If $N_1 = \frac{N}{3}$ and $\Delta_1 = \frac{\Delta}{3}$ or $\Delta_1 = 0$ (at constant $0 \le \Delta < 1$ and $0 \le \Delta_1 < 0.5$), then $Z_a = 3(Z_{r1} - \Delta_1) = 3[(N_1 + \Delta_1) - \Delta_1] = 3N_1 = N$; and $\underline{Z_a} = \underline{N}$ (17)

If $N_1 = \frac{N - 1}{3}$ and $\Delta_1 = \frac{1 + \Delta}{3}$, at $0 \le \Delta < 1$ and $0 < \Delta_1 \le 0.5$ (or $0.5 < \Delta_1 << 1$), then $Z_a = 3(Z_{r1} - \Delta_1) = 3\left[\left(\frac{N - 1}{3} + \frac{1 + \Delta}{3}\right) - \frac{1 + \Delta}{3}\right] = N - 1$; and $\underline{Z_a} = \underline{N - 1}$ (18)

If $N_1 = \frac{N - 2}{3}$ and $\Delta_1 = \frac{2 + \Delta}{3}$, at $0 < \Delta < 0.5$ and $0.5 < \Delta_1 < 1$, then $Z_a = 3(Z_{r1} - \Delta_1) = 3\left[\left(\frac{N - 2}{3} + \frac{2 + \Delta}{3}\right) - \frac{2 + \Delta}{3}\right] = N - 2$; and $\underline{Z_a} = \underline{N - 2}$ (19)

If $N_1 = \frac{N - 2}{3}$ and $\Delta_1 = \frac{2 + \Delta}{3}$, at $0.5 < \Delta < 1$ and $0.5 << \Delta_1 < 1$, then $Z_a = 3[(Z_{r1} - (\Delta - 1))] = 3\left[\left(\frac{N - 2}{3} + \frac{2 + \Delta}{3}\right) - \left(\frac{2 + \Delta}{3} - 1\right)\right] = N + 1$; and $\underline{Z_a} = \underline{N + 1}$ (20)

$$i_a = \frac{i \cdot Z_c - \Delta}{Z_c} = i - \frac{\Delta}{Z_c} \quad (21)$$

$$Z_a + 1 = Z_r - \Delta;\ Z_a = Z_r - (1 + \Delta);\ i_a \cdot Z_c - (1 + \Delta);\ i_a = \frac{iZ_c - (1 + \Delta)}{Z_c} = i - \frac{1 + \Delta}{Z_c} \quad (22)$$

$$Z_a + 2 = Z_r - \Delta;\ Z_a = Z_r - (2 - \Delta);\ i_a \cdot Z_c = i \cdot Z_c - (2 + \Delta);\ i_a = \frac{iZ_c - (2 + \Delta)}{Z_c} = i - \frac{2 + \Delta}{Z_c} \quad (23)$$

$$Z_a - 1 = Z_r - \Delta;\ Z_a = Z_r - (\Delta - 1);\ i_a \cdot Z_c = i \cdot Z_c - (\Delta - 1);\ i_a = \frac{i \cdot Z_c - (\Delta - 1)}{Z_c} = i - \frac{\Delta - 1}{Z_c} = i + \frac{1 - \Delta}{Z_c} \quad (24)$$

Nomenclature

t	= rack pitch, mm
t_c	= pitch of heel teeth, each once
t'	= increased pitch of one of the well bottom rack craters
Z_c	= number of heel teeth, each once
d	= gauge tip diameter of the cone
D	= diameter of the cone
Z_{cr}	= number of craters
Z_{rd}	= number of ridges between the craters
Z_r	= estimated number of the "teeth" on the hole bottom rack
$i = \frac{D}{d}$	= gear ratio for the cones at pure rolling
i_a	= actual gear ratio
N	= an integral number
Δ	= a fractional number, while $0 \le \Delta < 1$
S	= skidding path
$BB' - S_1 = \frac{\delta}{\sin \alpha/2}$	= skidding path of the heel row of a single cone/revolution of the bit when rotation is slowed - down, where $0 < \Delta \le 0.5$
$AA' = S_2 = \frac{\delta - t}{\sin \alpha/2}$	= skidding path of the heel row of a single cone/revolution of the bit when rotation speeds up, where $0.5 << \Delta < 1$
$S_z = \frac{S}{3}$	= slide path for three "completing" teeth
α	= angle of natural rock spalling
$Z_r = \frac{N + \Delta}{3}$	= number of teeth on bottom hole rack
$F - F_{rl} + F_s$	= driving force
F_{rl}	= rolling force
F_s	= sliding force

assuming that it has been rolled by one of the cones, for cases when $Z_r = N$ (Fig. 1a), $Z_r = N + \Delta$ at $0 < \Delta \le 0.5$ (Fig. 1b), and $Z_r = N + \Delta$ at $0.5 << \Delta < 1$ (Fig. 1c). The line "mn" tentatively marks the boundary where the cone starts its movement in the direction shown by the arrow. The points A, B, and C mark the position of the cone teeth when the bit completes one revolution and starts the next one.

Sections BB' and AA' are the paths of the teeth skidding as the result of their sliding down to the bottomhole rack after one revolution of the bit. The

direction of the teeth sliding down will determine the movement of the cone: the motion will be either slowed (BB' – the slow-down path, Fig. 1b) or accelerated (AA' – the speed-up path, Fig. 1c).

The phenomenon of the teeth sliding onto the craters was first observed by L.P. Konstantinov and R.M. Eygeles during high-speed filming of the three-cone bit performance.[3] Afterwards, this condition was used when analyzing the cone kinematics.[4]

As shown in Figs 1b and 1c, if a single cone is viewed in the course of one bit revolution, one of the teeth will skid (the tooth is in the 'B' position in Fig.1b and in the 'A' position in Fig. 1c). The tooth in the 'C' position (Fig. 1b) and in the 'B' position (Fig. 1c), when cone rotation is continued, will reroll without any slippage due to the pitch equality of the cone teeth and the rack teeth. It is quite evident that at $Z_r = N$ (Fig. 1a) the cone will roll over the hole bottom without any skidding.

Thus, the fractional part of the rack pitch δ (Figs. 1b and 1c), equal to $\delta = \Delta \cdot t$, will determine the magnitude and the direction of the cone skidding per single revolution of the bit.

Looking at the two skidding paths, BB' (rotation slowed) and AA' (rotation accelerated), and a range for rock spalling angle[5] (α) of 120-140^0 (assume $\alpha = 120^0$), we reach Equation 5.

In general, disregarding the sin α/2 value, we calculate S, S_1, and S_2 in Equation 6.

Triple-cone example

Now, moving from the calculations for a single cone to an actual case in which the bottomhole rack was formed by three cones, our considerations are as follows:

Assume that the bottomhole rack will be formed at a one-third revolution of the bit (Fig. 2). Each cone will roll its own row (sector) of the "teeth." Equation 7 calculates their estimated number.

Fig. 3 confirms the validity of this assumption and presents a picture of a steel hole bottom rolled by a commercial B-190T bit with varied pitch of the heel teeth in all cones.

The profile pattern of the peripheral rack formed when the steel hole bottom was drilled evidently confirmed the possible existence of three differing sectors on the bottomhole surface during drilling with a three-cone rock bit. The photograph distinctly shows the borders of these sectors where rearrangement of the rack teeth takes place.

Naturally, it is difficult visually to estimate the difference in magnitude of the teeth pitch of individual rack sectors because of minor variances in the teeth pitch of the heel rows of the cones. (The difference between maximum and minimum pitch for the heel teeth equals 1.95 mm.) However, closer examination reveals the difference, which was confirmed when the value of the rack teeth pitch was measured.

Fig. 4 shows a more convincing picture of the different bottomhole sectors, the metallic hole bottom formed by the 191K-214 MC-2 two-cone bit, with a 3.7-mm difference in the pitch of the heel rows of the cones. Since this is a two-cone bit, there are two sectors on the hole bottom that differ sharply in their profile.

The hypothesis concerning different sectors of rock destruction is also confirmed in Fig. 5, which shows the profile of the peripheral part of the hole bottom formed by the B-190T three-cone bit during drilling of marble.

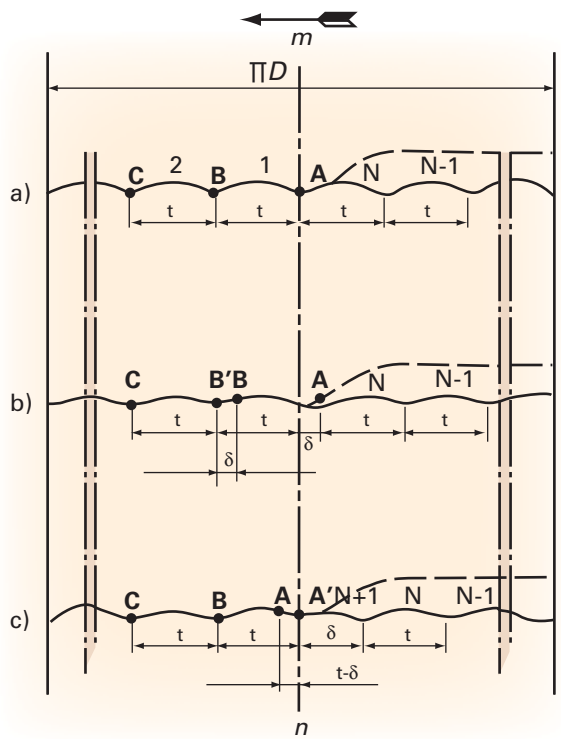
Based on the experimentally confirmed assumption of the existence of three destruction sectors on the hole bottom during drilling with three-cone bits, we may assert that all our considerations expressed in favor of the bottomhole rack formed by a single cone will be valid for the bit with equal pitch of the heel teeth for all cones.

Here, however, the following condition should be taken into account. If it turns out that N1 = N/3 and $\Delta_1 = \Delta/3$, i.e., the integral part of Z_r value may be divided evenly in three without remainder, then the difference in kinematics of the three-cone combination vs. a single cone will be as follows: each cone, per revolution of the bit, will slide three times for the amount $\delta_1 = \delta/3 = \Delta_1 \cdot t$, i.e., the skidding path, or slide, $S = 3\delta_1 = \Delta \cdot t$.

This means that not all heel teeth of the cones will be subject to slide during each revolution of the bit. Only those that complete the motion of the cone in

FORMATION PATTERN OF PERIPHERAL RACK*

Fig. 1



*For revolution of one cone only, N represents the last "tooth" of the rack.

each of the sectors of the well bottom rack will skid.

'Completing' teeth

In the general case, there will be three teeth, which we can dub "completing teeth." Their slide path would be S_z.

After each bit revolution, the completing teeth may be either replaced by other teeth or remain constant. That depends upon the actual value of the gear ratio of the cones, i_a.

In particular, if $i_a = 1.5$ or is close to that value, i.e., if each sector of the well bottom rack accounts for 0.5 of the bit revolution, then two diametrically opposed heel teeth of the cones may constantly remain as the "completing" ones. Accordingly, $(Z_c \cdot i_a)/3 = 0.5 \cdot Z_c$ or $(Z_c \cdot i_a)/3 \approx 0.5 \cdot Z_c$.

As to wear resistance of the completing teeth, such a value for the actual bit ratio is not quite desirable because it may lead to fatigue wear and chipping of the teeth resulting from the constant lateral forces, induced by skidding of the cones.

However, if i_a does not equal or come close to 1.5, so that, $(Z_c \cdot i_a)/3 < 0.5 \cdot Z_c$ or $(Z_c \cdot i_a)/3 > 0.5 \cdot Z_c$, then, after each revolution of the bit, the completing teeth will replace one another, resulting in a more even wear of the cone's cutting structures.

Nevertheless, this does not mean that when designing bits one must design the actual bit ratio to be something other than 1.5. In each individual case, one should consider the path of the teeth sliding, which at $i_a = 1.5$, might happen to be substantially less than it is at other gear ratios of the cones.

Another difference in kinematics of the three-cone bit as compared to the single-cone bit, as we ascertained, lies in the fact that when considering a single cone at $\Delta > 0.5$, one observes rotary acceleration and skidding equal to $S_2 = t(\Delta - 1)$.

Acceleration, deceleration

Considering three cones precludes acceleration since Δ_1 in this case is always less than 0.5. The cone skidding, consequently, would be slowed down, equal in its absolute value to $S_1 = \Delta_1 t$.

In the general case, when $N_1 \neq N/3$ and $\Delta_1 \neq \Delta/3$, i.e., the integral part of Z_r value divides in three with a remainder, then, passing from a single cone to three cones, both slowing (at $0 < \Delta_1 \leq 0.5$) and acceleration (at $0.5 < \Delta_1 < 1$) of rotation are possible. Moreover, at such transition the phenomenon of acceleration or deceleration may either remain or reverse. The slowing (or acceleration) may even increase, moving more slowly. We can confirm it by the following considerations:

As $N_1 \neq N/3$, dividing N by three gives a remainder of 1 or 2. Consequently,

$N_1 \neq (N-1)/3$ or $N_1 = (N-2)/3$ or, accordingly, $\Delta_1 = (1 + \Delta)/3$ or $\Delta_1 = (2 + \Delta)/3$.

If $0 < \Delta \leq 0.5$ (slow-down), then at $\Delta_1 = (1 + \Delta)/3$ we have $0 < \Delta_1 \leq 0.5$, i.e., slow-down occurs, while at $\Delta_1 = (2+\Delta)/3$ we have $0.5 < \Delta_1 < 1$, i.e., acceleration or slow-down may occur.

If $0.5 < \Delta < 1$ (acceleration), then at $\Delta_1 = (1+\Delta)/3$ we have $0.5 < \Delta_1 < 1$, i.e., slow-down occurs, and at $\Delta_1 = (2+\Delta)/3$ we'll have $0.5 < \Delta_1 < 1$, i.e., acceleration occurs.

At that, the slide path for the heel rows of each of the three cones per revolution of the bit at slow-down of rotation will be equal to S'_1 as shown in Equations 8 or 9.

During acceleration, the path will be S'_2, as shown in Equation 10. Therefore, $S'_1 \geq S'_1$ and $S'_2 \geq S_2$, where S'_1 and S'_2 are accordingly the paths of the decelerated and accelerated skidding of the heel rows of each of the three cones, per revolution of the bit.

Keeping in mind that the slide paths of the cone rows account for the three completing teeth, one solves Equation 11 to find the slide path of one of such teeth.

Thus, at $Z_1 = Z_2 = Z_3$, both deceleration and acceleration of the cone rotation are possible, as conditioned by the value of Z_r and the phenomenon of the cone teeth skidding down into the craters of the well bottom rack.

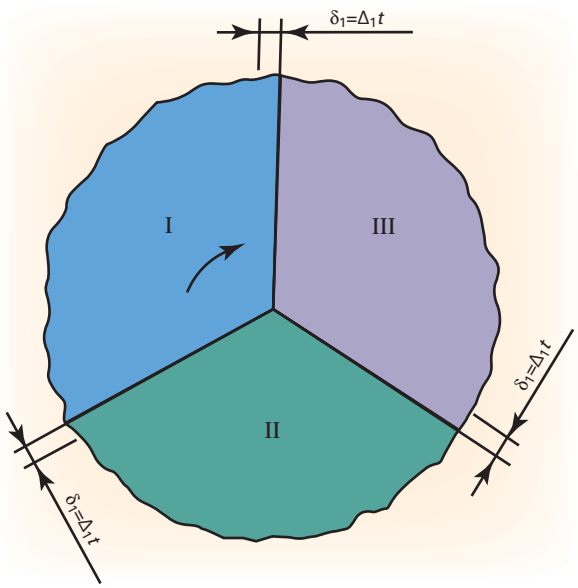
Fig. 6 illustrates the pattern of the teeth skidding into the craters of the rack at the decelerated (Fig. 6a) and accelerated (Fig. 6b) rotation of the cones.

Driving force

As shown in Fig. 6a, the process of slowing the cone rolling over the well bottom rack associated with the skidding of the teeth in the direction of rolling along the line BB' is conditioned by summing up of the rolling (F_{rl}) and sliding (F_s) forces, $F_1 = F_{rl} + F_s$. The driving force F_1 does not impede but, on the contrary, promotes skidding of the teeth down into the crater. This

HOLE BOTTOM DESTRUCTION SECTORS

Fig. 2



process may be observed in hard and soft formations.

Meanwhile, accelerated cone rotation is associated with the teeth skidding in a direction opposite the rolling along the line AA' (Fig. 6b). In this case, the driving force $F_2 = F_{rl} + F_s$ impedes the teeth skidding and tends to destroy the ridge between the craters.

Varying rock strength

At high rock strength, if there is low torque at the cone, and consequently, low rolling force, the sum of forces $F_2 = F_{rl} + F_s$ will not be sufficient to destroy the ridge. The teeth will have to slip along the line AA', as shown in Fig. 6, and the cone will accelerate. A similar result occurs when drilling at low axial loads.

However, low rock strength promotes an increase in cone torque and rolling force at the expense of greater depth of the tooth penetration into the rock. The ridge between the craters, under the impact of the force $F_2 = F_{rl} + F_s$ will be destroyed and the tooth will assume its movement along the line AA'' (Fig. 6b). This movement will be provoked by the sum of forces $F^1 = F_{rl} + F'_s$ and will result, instead of acceleration, in slowing down the cone rotation.

In other words, if considering geometric relationships of the well bottom rack and the cone permits us to draw this conclusion concerning the slowing of the cone rotation, it should be valid for rock of any strength. At the same time, if the geometric forecast points to accelerating cone rotation, it will be valid for rock of high strength as well as in cases when drilling is performed at low axial loads. In low-strength rock, the process of the cone rotation slowing down is most probable.

Calculating Z_a

Thus, returning to Fig. 1 and taking into account that the actual number of the teeth of the rack Z_a, as distinct from the estimated number, is an integral value, we may calculate three values for the number of teeth on a single cone. Equation 12 calculates the number for the pure rolling case; Equation 13 is used for slowed skidding and Equation 14 is used for accelerated skidding.

A commercial B-190T bit with varied pitch of the heel teeth in all cones rolled this steel bottomhole pattern (Fig. 3).

A 191K-214 MC-2 two-cone bit with a 3.7-mm difference in the pitch of the heel rows of the cones formed this metallic bottomhole pattern (Fig. 4).

These three equations indicate that for a single cone, two values of the actual number of the rack teeth are possible. One value corresponds to the integral part of the estimated number of the rack teeth (at $0 \leq \Delta \leq 0.5$), while the other is greater by one (at $0.5 << \Delta < 1$).

It is interesting to note that when there is no skidding (when $\Delta = 0$) and at slowed skidding (when $0 < \Delta \leq 0.5$), the actual number of rack teeth is the same (N). The difference lies in the increase of the pitch of one of the craters for the value $\delta = \Delta \cdot t$, at slowed rotation of the cone (Fig. 1b), shown in Equation 15.

At the accelerated skidding, $Za = N + 1$, i.e., when an additional crater is created (Fig. 1c), the pitch of the additional crater is shown by Equation 16.

Three cones

Passing from the single cone to the three-cone combination and taking into account Equation 7, we calculate the actual number of teeth, Z_a, using Equations 17-20.

Considering Equations 17-20, we see that, during drilling with three-cone bits at $Z_1 = Z_2 = Z_3$, formation of the well bottom rack occurs with four different values for the actual number of teeth: N, N–1, N–2, and N+1 (N, as mentioned before, is an integral part of the estimated number of the rack teeth):

- At $Z_a = N$, there may be pure rolling or a slowing of the cone rotation.
- At $Z_a = N–1$ or at $Z_a = N–2$ there may be a slowing of the cone rotation.
- At $Z_a = N+1$ there will be acceleration of the cone rotation.

Factors, assertions

Thus, the geometry of the well bottom rack and the character of the multicone bit's cutter movement (in particular, the three-cone bit with equal heel teeth pitch), are determined by three factors:

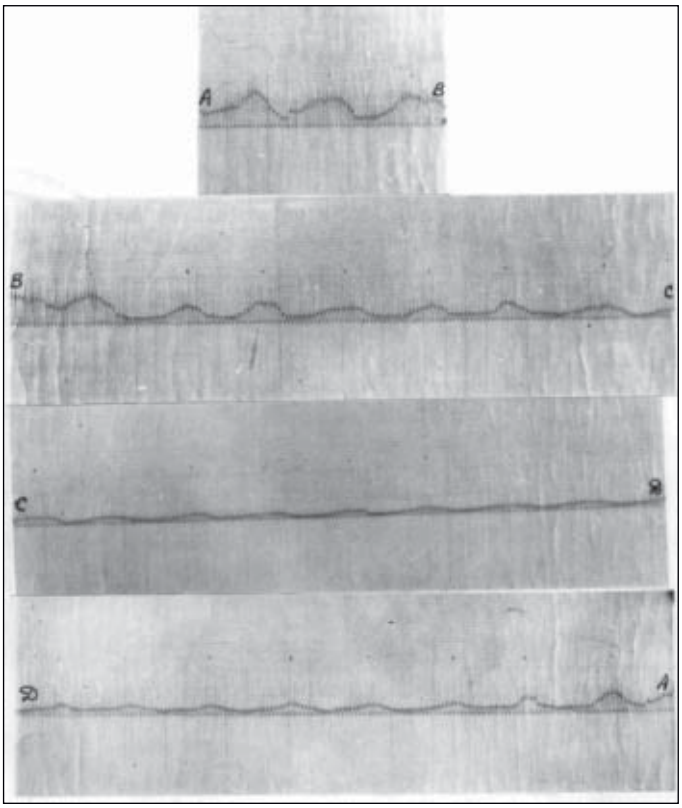
1. The relationship of the bit diameter and the gauge tip diameter of the cones, i.e., by the value of the cone gear ratio i at their pure rolling.
2. The number of the heel teeth on each of the cones Z_c.
3. Physical and mechanical rock properties.

Consequently, we may assert that:

- If $N_1 = N/3$, and $\Delta = 0$, i.e., when the estimated number of the well bottom rack teeth is divisible by three without a remainder, then $Z_a = N$, $Z_r = N$, and $Z_a = Z_r$. Since $Z_a = i_a \cdot Z_c$ and Z_r

$= i_a \cdot Z_c$ where i_a is the actual gear ratio of the cones, then $i_a \cdot Z_c = i \cdot Z_c$ and $i_a = i$. Consequently, the actual gear ratio of the cones in this case will correspond to pure rolling and there will be no skidding of the gauging part of the teeth as conditioned by the cone geometry.

This assertion is evidently reasonable both for single and multicone bits of the reviewed designs as all considerations concerning the effects of the cones' number and their geometric perfection on the cone kinematics and the position of the instantaneous axis of rotation[1] are valid only for smooth-tapered cones and are unfit for toothed cones as kinematics of the latter are mostly determined by the interaction of the heel rows with the well bottom rack, by analogy to toothed gearings.



This profile shows the peripheral part of the hole bottom formed by a B-190T, three-cone bit while drilling marble (Fig. 5).

The difference between the single- and multicone bit designs in the given case lies in the fact that considering the perfect cone, pure rolling would be observed at any point of the cone generatrix (generated by a geometric element; Fig. 7a), while in the case of an imperfect cone, any generatrix point, excluding the peripheral one, would skid with acceleration (Fig. 7b).

Back to considering problems of bit kinematics, in particular, the absence of skidding of the gauge teeth at $Z_a = N$, we proceed from the cone geometry and do not consider the phenomenon of the cone skidding due to the cutting structure and the rock interaction. According to our data, the amount of such skidding is relatively small; its specific value is less than 1% and therefore it may be neglected.[6]

- If $N_1 = N/3$, $\Delta_1 = \Delta/3$, and $0<\Delta<1$, i.e., when the integral part of the estimated number of the rack teeth divides by three without a remainder, then, according to Equation 17, $Z_a = N$ and $Z_r = N+\Delta$. This means that $Z_a<Z_r$ or $i_a \cdot Z_c < i \cdot Z_c$, and $i_a<i$. Consequently, the actual gear ratio for the cones in this case will be less than in the case of pure rolling.

To calculate the difference in values of the given cone gear ratios, keep in mind that $Z_a = Z_r-\Delta$, we put down: $i_a \cdot Z_c = i \cdot Zc-\Delta$, which leads to Equation 21.

As we see, the actual gear ratio for the cones at $Z_1 = Z_2 = Z_3$, $N_1 = N/3$ and $0<\Delta<1$ is less than in the case of pure rolling for the value Δ/Z_c.

- If $N_1 = (N-1)/3$, $\Delta = (1+\Delta)/3$, and $0<\Delta<1$, i.e., when the integral part of Z_r is divisible by three, with a remainder of 1, then, according to Equation 18, $Z_a = N-1$ and $Z_r = N+\Delta$. This means that $Z_a<Z_r$ and $i_a<i$.

Equation 22 shows the difference in i_a and i values.

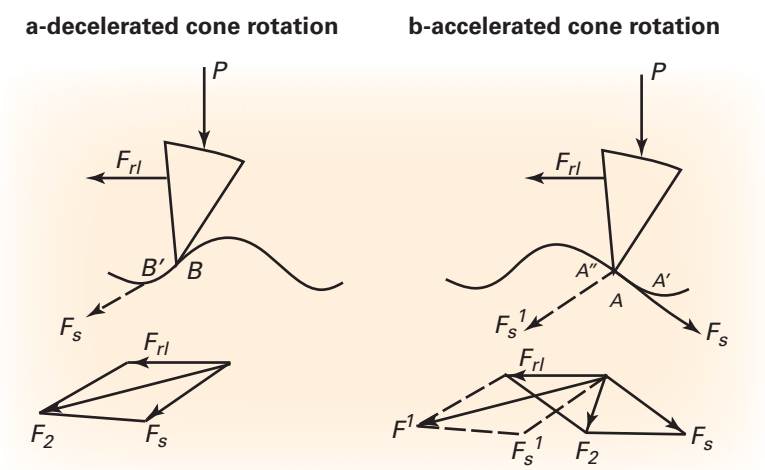
Comparing Equations 21-22, we see that i_a in the given case is substantially less than the previous (for the value of $1/Z_c$), and the slowed skidding of the cones, consequently, will be more pronounced.

- If $N_1 = (N-2)/3$, $\Delta_1 = (2+\Delta)/3$, and $0<\Delta<0.5$, i.e., when the integral part of Z_r value divides by three with a remainder equal to 2, and $0<\Delta<0.5$, then, according to Equation 19, Za = N–2, but $Z_r = N+\Delta$. This means that $Z_a<Z_r$ and $i_a<i$. The value of i_a can be calculated by Equation 23.

- If $N_1 = (N-2)/3$, $\Delta_1 = (2+\Delta)/3$,

CONE TEETH SKIDDING INTO CRATERS OF RACK

Fig. 6



and $0.5 << \Delta < 1$, i.e., when the integral part of Z_r value divides by three with a remainder equal to 2, and $0.5 << \Delta < 1$, then, according to Equation 20, $Z_a = N+1$, and $Z_r = N+\Delta$. This means that $Z_a > Z_r$ and $i_a > i$, and the calculation of i_a is shown by Equation 24.

As shown in Equation 24, the actual gear ratio for the cones at $Z_1 = Z_2 = Z_3$, $N_1 = (N-2)/3$, and $0.5 << \Delta < 1$ is greater than that at pure rolling for the value $(1-\Delta)/Z_c$.

ESTIMATED VALUES FOR STANDARD B-190T BITS*

Table 1

Z_c	t, mm	Z_r	Δ, $1+\Delta$, $1-\Delta$, $2+\Delta$	$\frac{\Delta}{Z_c}; \frac{1+\Delta}{Z_c}; \frac{1-\Delta}{Z_c}; \frac{2+\Delta}{Z_c}$	i_a	S, mm	S_z, mm	Z_a
4	97.5	6.13	0.13	0.03	1.5	12.48	4.16	6
5	78	7.66	1.66	0.33	1.2	129.0	43.0	6
6	65	9.19	0.19	0.03	1.5	12.48	4.16	9
7	55.7	10.72	1.72	0.24	1.29	96.0	32.0	9
8	48.75	12.25	0.25	0.03	1.5	12.48	4.16	12
9	43.3	13.79	1.79	0.19	1.33	77.4	25.8	12
10	39	15.32	0.32	0.03	1.5	12.48	4.16	15
11	35.4	16.85	1.85	0.17	1.36	65.5	21.8	15
12	32.5	18.38	0.38	0.03	1.5	12.48	4.16	18
13	30	19,92	1.92	0.15	1.38	57.5	19.2	18
14	27.8	21.45	0.45	0.03	1.5	12.48	4.16	21
15	26	22.98	1.98	0.13	1.4	51.5	17.2	21
16	24.3	24.51	0.51	0.03	1.5	12.48	4.16	24
17	22.9	26.04	2.04	0.12	1.41	46.8	15.6	24
18	21.6	27.57	0.57	0.03	1.5	12.48	4.16	27
19	20.5	29.11	2.11	0.11	1.42	43.2	14.4	27
20	19.5	30.64	0.64	0.03	1.5	12.48	4.16	30
21	18.5	32.17	2.17	0.10	1.43	40.1	13.4	30
22	17.7	33.70	0.70	0.03	1.5	12.48	4.16	33
23	16.9	35.23	2.23	0.09	1.43	37.8	12.6	33
24	16.2	36.77	0.77	0.03	1.5	12.48	4.16	36
25	15.6	38.30	2.30	0.09	1.44	35.9	12.0	36
26	15	39.83	0.83	0.03	1.5	12.48	4.16	39
27	14.4	41.36	2.36	0.08	1.44	34	11.3	39
28	13.9	42.89	0.89	0.03	1.5	12.48	4.16	42
29	13.4	44.43	2.43	0.08	1.45	32.5	10.8	42
30	13	45.96	0.96	0.03	1.5	12.48	4.16	45

*Where D = 190 mm; d = 124 mm; i = 1.532.

Actual gear ratio

Thus, we have established that, if the pitch for the heel teeth of all bit cones is equal, i.e., $Z_1 = Z_2 = Z_3 = Z_c$, then, depending upon the values of i and Z_c, the actual gear ratio for the cones, i_a, may have five values:

1. $i_a = i$ – pure rolling of cones, at $N_1 = N/3$; $\Delta = 0$; $Z_a = N$.
2. $i_a = i - (\Delta/Z_c)$ – slowed-down rotation of the cones, at $N_1 = N/3$; $\Delta_1 = \Delta/3$; $0<\Delta<1$; $Z_a = N$.
3. $i_a = i - ((1+\Delta)/Z_c)$ – slowed-down rotation of the cones, at $N_1 = (N-1)/3$; $\Delta_1 = (1+\Delta)/3$; $0<\Delta<1$; $Z_a = N-1$.
4. $i_a = i - ((2+\Delta)/Z_c)$ – slowed-down rotation of the cones, at $N_1 = (N-2)/3$; $\Delta_1 = (2+\Delta)/3$; $0<\Delta<0.5$; $Z_a = N-2$.
5. $i_a = i + ((1+\Delta)/Z_c)$ – accelerated rotation of the cones, at $N_1 = (N-2)/3$; $0.5<<\Delta<1$; $Z_a = N+1$.

It is evident that $Z_c \rightarrow \infty$, $i_a = i$.

When you analyze these formulas that predict the actual gear ratios for cones with equal tooth pitch for all heel rows, pay attention to the following:

- Just as the actual gear ratio for the cones of each standard size bit in the case of pure rolling has its individual value i = const., the actual gear ratio for the cones of this bit (with equal number of the heel teeth on all the cones) will completely depend on the number of teeth on a single cone.
- For bits that differ in size but have the same i value, the actual gear ratio of their cones will be equal when they have an equal number of heel teeth. But as the heel teeth pitch will depend upon the size of the bit, the cones with equal values of i_a will have different amounts of skidding.

Taking into consideration that the gear ratio for the cones of the standard three-cone bits in the case of pure rolling is somewhere in the range $i = 1.5 \div 1.6$, i.e., $i = (3/2) + \xi$, and being aware that $i \cdot Z_c = N+\Delta$, we can write: $(3/2 + \xi) \cdot Z_c = N+\Delta$ or $(3/2) \cdot Z_c + \xi \cdot Z_c = N+\Delta$.

Thus, if Z_c is an even number, then $(3/2) \cdot Zc = N$, while $\xi \cdot Z_c = \Delta$. Consequently, if Z_c is an even number, then $N = 3 \cdot (Z_c/2) = Z_a$, while if Z_c is an uneven number, then $N' = 3 \cdot (Z'_c/2) = Z_c \cdot Z'_c$ is the nearest to Z_c even number, i.e., $Z'_c = Z_c \pm 1$. This means that with an equal number of heel teeth on all cones, Z_c, the actual number of well bottom teeth Z_c should be divisible by three. Besides, if Z_c is an even number, then $i_a = Z_a/Z_c = ((3/2)Z_c)/Z_c = 3/2 = 1.5$.

This agrees with test-stand studies of rock-bit kinematics with heel rows made in the form of circumferential teeth.[7] These bits have an equal number of heel teeth on all cones, $Z_c = 10$. In all drilling tests, the rack formed in the angular zone of the well bottom with 15 teeth ($Z_a = 15$), and the same number of textural marks (grooves) was formed on the well wall. Accordingly, the actual gear ratio for the cones was $i_a = Z_a/Z_c = 15/10 = 1.5$, confirmed by the recorder.

It's notable to mention that the circumferential teeth form a more conservative geometry in the well bottom rack when compared with the geometry formed by longitudinal teeth. This means that if cones with longitudinal teeth can form the well bottom rack with varying number of craters, depending upon rock properties and differing operational and technological factors, then the cones with equal-pitch circumferential heel teeth will form the

ESTIMATED VALUES FOR STANDARD B-151T, K-214T BITS*

Table 2

Z_c	t, mm		Z_r	Δ, 1+Δ, 1–Δ, 2+Δ	$\frac{\Delta}{Z_c}; \frac{1+\Delta}{Z_c}; \frac{1-\Delta}{Z_c}; \frac{2+\Delta}{Z_c}$	i_a	S, mm		Sz, mm		Z_a
	t_1	t_2					S_1	S_2	S_{z1}	S_{z2}	
4	75.25	106.7	6.29	0.29	0.07	1.5	21.9	31.1	7.3	10.4	6
5	60.2	85.4	7.86	1.85	0.37	1.2	112.2	159.2	37.3	53.1	6
6	50.1	71.1	9.34	0.44	0.07	1.5	21.9	31.1	7.3	10.4	9
7	43.0	61.0	11.01	2.01	0.29	1.28	86.4	122.6	40.9	40.9	9
8	37.6	53.3	12.58	0.58	0.07	1.5	21.9	31.1	7.3	10.4	12
9	33.4	47.4	14.16	2.16	0.24	1.33	72.0	102.2	24	34.1	12
10	30.1	42.7	15.73	0.73	0.073	1.5	21.9	31.1	7.3	10.4	15
11	27.3	38.8	17.30	2.30	0.21	1.36	62.8	89.3	20.9	29.8	15
12	25.1	35.5	18.87	0.87	0.07	1.5	21.9	31.1	7.3	10.4	18
13	23.1	32.8	20.45	2.45	0.19	1.38	56.6	80.3	18.8	26.8	18
14	21.5	30.5	22.02	1.02	0.07	1.5	21.9	31.1	7.3	10.4	21
15	20.0	28.4	23.59	0.41	–0.03	1.6	–8.1	–11.5	–2.7	–3.8	24
16	18.8	26.6	25.17	1.17	0.07	1.5	21.9	31.1	7.3	10.4	24
17	17.7	25.1	26.74	0.26	–0.02	1.59	–4.6	–6.5	–1.5	–2.2	27
18	16.7	23.7	28.31	1.31	0.07	1.5	21.9	31.1	7.3	10.4	27
19	15.8	22.5	29.89	0.11	–0.01	1.58	–1.8	–2.5	–0.6	–0.8	30
20	15.1	21.3	31.46	1.46	0.07	1.5	21.9	31.1	7.3	10.4	30
21	14.3	20.3	33.03	0.03	0.00	1.57	0	0	0	0	33
22	13.7	19.4	34.61	0.07	0.07	1.5	21.9	31.1	7.3	10.4	33
23	13.1	18.5	36.18	0.18	0.01	1.56	2.3	3.3	0.78	1.1	36
24	12.5	17.8	37.75	1.75	0.07	1.5	21.9	31.1	7.3	10.4	36
25	12.1	17.1	39.32	0.32	0.32	0.01	1.56	5.5	1.3	1.8	39
26	11.6	16.4	40.90	1.90	0.07	1.5	21.9	31.1	7.3	10.4	39
27	11.1	15.8	42.47	0.47	0.02	1.55	5.2	7.4	1.7	2.5	42
28	10.7	15.2	44.04	2.04	0.07	1.5	21.9	31.1	7.3	10.4	42
29	10.3	14.7	45.62	0.62	0.02	1.55	6.3	9.0	2.1	3.0	45
30	10.0	14.2	47.19	2.19	0.07	1.5	21.9	31.1	7.3	10.4	45

*Where D_1 = 151; d_1 = 96; i = 1.573; and D_2 = 214; d_2 = 136; i = 1.573.

well bottom rack with a constant number of craters in all drilling cases.

Test results

During drilling with 20B-151T drillbits (manufactured following the standard B-151T bit design, with an equal number of peripheral longitudinal teeth on all cones, Z_c = 20), testers recorded i_a = 1.5, indicating that the well bottom rack had 30 peripheral craters.

Tables 1 and 2 present estimated values Z_r, Z_a, i_a, S, and S_z for the B-151T, B-190T, and K-214T bits. All three bit cones have equal numbers of heel teeth, Z_c, across a wide range from Z_c = 4 (a bit with such number of the teeth was some time ago recommended by Vladislavlev[4]) to Z_c = 30.

As seen from the tables, the actual gear ratio for cones with equal pitch of heel row teeth may correspond to pure rolling, not only at large and unpractical numbers of heel teeth, Z_c, but also at some lower, practical Z_c values.

For instance, with the B-151T and K-214T bits, which have the same gear ratio i = 1.573, i_a = i at Z_c = 21, while for the B-190T bit, i_a = i is behind the range of practically justified Z_c values (i_a = i, e.g., at Z_c = 49).

This means that in order to minimize rock bit cutting structure skidding, there should be 21 heel teeth on all cones of the 151-mm and 214-mm bits. But on similar cones of 190-mm bits, there should be an even number of heel teeth.

Commonalities

Thus, when there is an equal number of heel teeth on all cones, the following commonalities are seen in three-cone bit kinematics:

1. The actual number of the rack teeth tends to be divisible by three because the well bottom rack in the given case consists of three equal sectors. A certain number of the teeth has been rolled in each of the sectors.

2. If the cones have an even number of heel teeth, their actual gear ratio tends to be 1.5.

3. For some bit sizes (e.g., 151-mm and 214-mm), the actual gear ratio for the cones may correspond to pure rolling at definite, practically applicable numbers of cone heel teeth.

4. The cones make a threefold skidding of their completing teeth per revolution of the bit. The path of their skidding is S_z = S/3, where S is the path of the given heel row skidding per revolution of the bit.

5. At i_a = 1.5, the skidding path S_z = S/3 constantly falls at some two diametrically opposite teeth of the given row of each cone, while at i_a values different from 1.5, the skidding path S_z = S/3 during the bit rotation is equally redistributed between all teeth of the given row.

Kinematics of bits of the double- and multiple-cone design can be analyzed in the same way. It should be taken into account that in each individual case, the number of sectors of destruction on the well bottom will be equal to the number of the bit cones. ✦

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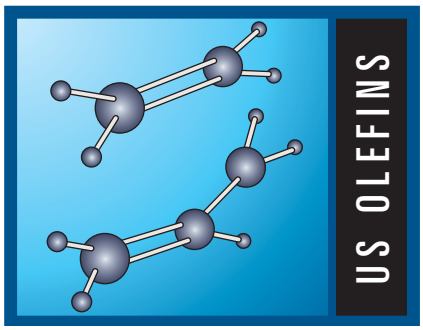
SECOND-HALF 2007

US olefins see improving feed economics, demand

Dan Lippe
Petral Worldwide Inc.
Houston



Although the US hurricane season of 2007 was essentially a non-event for the petrochemical and refining industries at large, Hurricane Humberto disrupted operations for a few weeks for ethylene producers in the Beaumont-Port Arthur, Tex., area during mid-September to early October. The important story for second-half 2007 was not Hurricane Humberto, however, but the persistent strength in demand for ethane.

Specifically, feedstock economics for ethane remained favorable and feedstock demand for ethane consistently averaged 47-48% of fresh feed during third-quarter 2007 and 48-51% during fourth-quarter 2007. The persistent strength in ethane demand limited coproducts yields of propylene and aromatics to 85-95% of year-earlier volumes.

Ethylene plant yields of propylene in particular were persistently lower than year-earlier volumes. Refinery-grade propylene sales were also lower than in 2006 and propylene availability was tight throughout second-half 2007.

US ETHYLENE FEED SLATE

Table 1

2007	Feed type, 1,000 b/d			
	Ethane	Propane	n-Butane	Naphthas, gas oils
April	799.2	354.5	96.9	438.3
May	798.4	377.5	87.6	434.2
June	817.0	364.9	113.7	440.5
July	834.0	351.9	122.6	446.7
August	811.3	335.5	113.7	509.1
September	742.2	302.6	26.6	499.1
October	797.0	314.2	43.7	508.8
November	843.1	278.3	29.1	525.0

Source: Petral Monthly Olefin Feedslate Survey

Olefin plant feed slates

Ethylene industry demand for fresh feed averaged 1.68 million b/d during third-quarter 2007; demand was slightly lower in fourth-quarter 2007 and averaged 1.66 million b/d. Demand for LPG feedstocks (ethane, propane, and n-butane) averaged 1.21 million b/d in third-quarter 2007 and declined to 1.15 million b/d in fourth-quarter 2007.

Due to a decline in LPG demand, ethylene producers cracked a somewhat heavier feed slate in fourth-quarter 2007. Specifically, LPG feeds accounted for 69% of total fresh feed in fourth-quarter 2007 vs. 72% of fresh feed in third-quarter 2007.

Typical seasonal factors resulted in lower demand for propane and n-butane, but demand for ethane remained robust during fourth-quarter 2007. Ethane's share of total fresh feed increased to 49.5% in fourth-quarter 2007 from 47.4% during third-quarter 2007.

Finally, ethane demand only fell below 780,000 b/d in September. Ethane demand was lower in September due only to Hurricane Humberto's effect on LPG crackers in the Beaumont-Port Arthur area for a few weeks.

Table 1 shows trends in olefin plants' fresh feed slates.

Based on projected ethylene industry operating rates of 90-92% for first-half 2008, total demand for fresh feedstocks will average 1.65-1.70 million b/d. Total demand for LPG feedstocks will average 1.15-1.20 million b/d during first-quarter 2008 and will increase to 1.20-1.25 million b/d during second-quarter 2008. LPG feedstocks will account for 68-70% of total fresh feed during first-quarter 2008 and 70-72% during second-quarter 2008.

Demand for ethane will remain strong and ethane's share of fresh feed will average 47-48% during first-half 2008.

Fig. 1 shows historic trends for ethylene feed slates.

Ethylene production

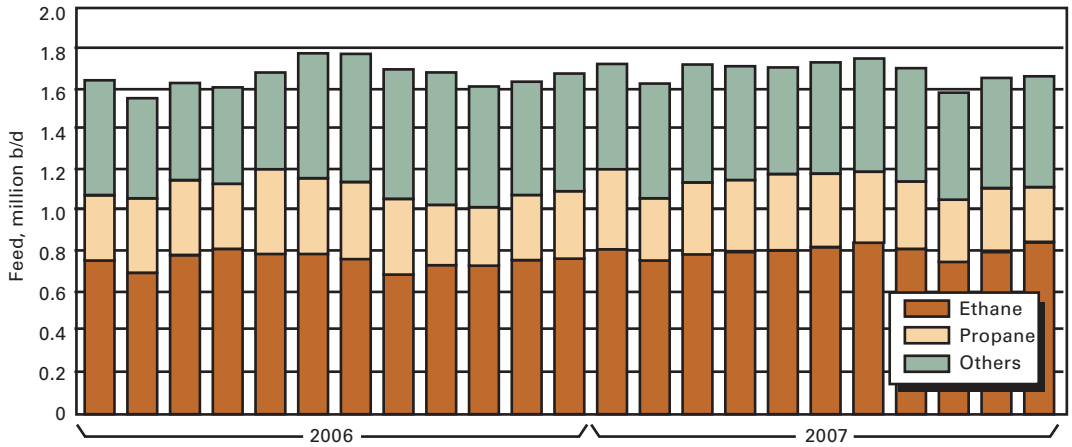
Ethylene production from fresh feed

was 13.70 billion lb in third-quarter 2007 but fell to 13.25-13.35 billion lb in fourth-quarter 2007 (Table 2). Ethylene production from steam crackers during third-quarter 2007 was 63 million lb less than in second-quarter 2007 (less than half a day's output). Production in fourth-quarter 2007 was 375 million lb less than in third-quarter 2007 (about 2.5 days of output).

Production from LPG plants totaled 5.07 billion lb in third-quarter 2007 and 4.80 billion lb in fourth-quarter 2007. Production in fourth-quarter 2007 was 250-275 million lb less than in third-quarter 2007 (about 5 days of production).

US ETHYLENE PLANT FEED SLATE

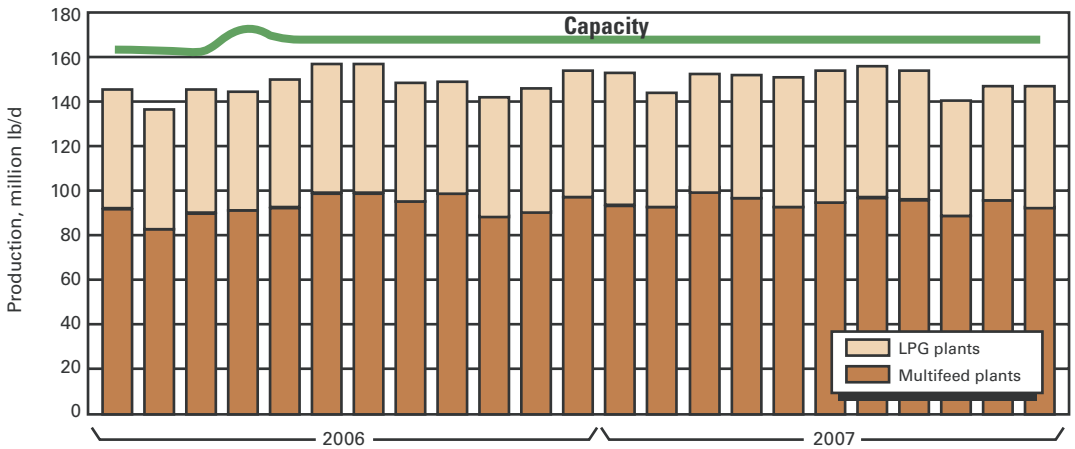
Fig. 1



Source: Petral Monthly Olefin Plant Feedslate Survey

US ETHYLENE PRODUCTION

Fig. 2



Source: Petral Monthly Olefin Plant Feedslate Survey

Production from multifeed crackers was 8.63 billion lb in the third quarter but declined to 8.50-8.60 billion lb in fourth-quarter 2007. Production from multifeed crackers during fourth-quarter 2007 was 100-110 million lb less than during third-quarter 2007 (about 1 day of production).

Operating rates for LPG crackers averaged 93% of nameplate capacity (21.6 billion lb/year) during third-quarter 2007 but declined to 89% during fourth-quarter 2007. Multifeed crackers operated at 89% of nameplate capacity (39.2 billion lb/year) during third-quarter 2007 and at 85-87% during fourth-quarter 2007.

Operating rates for the overall industry averaged 90.2% during third-quarter 2007 but slipped to 87% during fourth-quarter 2007. Turnarounds and Humberto's disruptions accounted for the decline in operating rates.

Flint Hills Resources LLC completed its acquisition of the ethylene plant at Port Arthur from Huntsman Corp. during third quarter. This plant resumed operations in October 2007 after being out of service following a fire in late April 2006. This ethylene plant, a multifeed cracker with 1.55-billion lb/year nameplate capacity, boosted the industry's nameplate ethylene production capacity to about 62 billion lb/year.

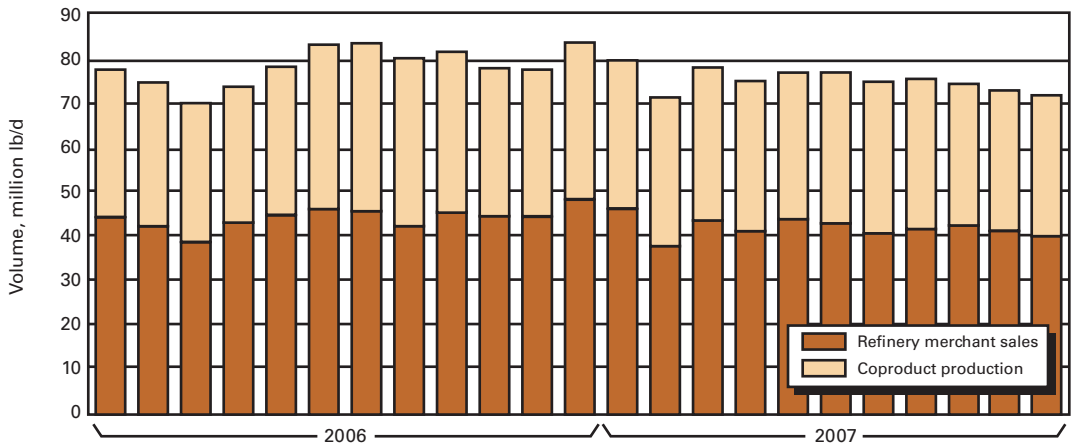
Fig. 2 shows trends in ethylene production.

US propylene production

Propylene production from steam crackers was 3.14 billion lb in third-quarter 2007, which was 19 million lb less than in second-quarter 2007 (less than 1 day of production). Coproduct propylene production during third-quarter 2007, however, was 370 million lb less than year-earlier volumes (11 days of production). Propylene production declined during the fourth quarter and totaled only 3.0 billion lb, which was 100-110 million lb less than

PROPYLENE PRODUCTION, SALES

Fig. 3



Source: Petral Monthly Coproduct Supply Analysis

during third-quarter 2007 (about 3 days of production).

Propylene production from LPG feeds was 1.39 billion lb in third-quarter 2007 and was 120 million lb less than production in second-quarter 2007. Propylene production from LPG feeds slipped to 1.1 billion lb during fourth-quarter 2007—almost 300 million lb less than during third-quarter 2007.

During fourth-quarter 2007, ethane cracking remained strong while propane and n-butane cracking declined. The sustained strength in feedstock demand for ethane was the most significant factor resulting in the 20% decline in coproduct propylene yields from LPG feeds during fourth quarter.

Propylene production from naphthas, condensates, and gas oils totaled 1.75 billion lb in third-quarter 2007 and was 98 million lb more than during second-quarter 2007. Coproduct yields of propylene from heavy feeds increased to 1.93 billion lb during fourth-quarter 2007, which was 179 million lb more than in third-quarter 2007.

Unless ethylene industry operating rates are significantly higher in first-half 2008 vs. second-half 2007, coproduct yields of propylene will continue to average 0.95-1.10 billion lb/month.

Table 3 shows trends in coproduct propylene production from LPG and multifeed plants.

ETHYLENE FROM US STEAM CRACKERS

Table 2

2007	Production, billion lb — LPG crackers	Multifeed crackers	Total
April	1.62	2.91	4.52
May	1.78	2.87	4.65
June	1.73	2.86	4.59
July	1.80	3.01	4.81
August	1.76	2.97	4.73
September	1.50	2.66	4.16
October	1.58	2.94	4.52
November	1.62	2.79	4.40

Source: Petral Monthly Ethylene Feedslate Survey

PROPYLENE FROM US STEAM CRACKERS

Table 3

2007	Production, million lb — LPG feeds	Naphtha, gas oil feeds	Est. prod.
April	483.6	564.2	1,047.8
May	509.3	556.7	1,065.9
June	513.8	532.5	1,046.3
July	531.2	557.0	1,088.2
August	503.8	567.1	1,070.9
September	351.5	627.7	979.2
October	398.6	636.9	1,035.5
November	340.5	626.7	967.3

Source: Petral Monthly Propylene Supply Analysis

Refinery propylene supply

Normally, refinery propylene production reaches its annual peak during third quarter. Refinery-grade propylene production during third-quarter 2007, however, was less than expected.

Refinery propylene sales were 3.8 billion lb during third-quarter 2007 (Table 4). Production was 45 million lb less than in second-quarter 2007 and 260 million lb less than year-earlier volumes (nearly 6 days of production). Refinery propylene sales slipped to 3.70-3.75 billion lb during fourth-quarter 2007.

Production in fourth quarter was 100-150 million lb less than in third quarter and 440 million lb less than year-earlier volumes (nearly 10 days of production).

The cumulative year-to-year decline in refinery propylene sales during second-half 2007 totaled 700 million lb. The year-to-year decline in refinery propylene sales reinforced weak coproduct propylene yields and kept total propylene supply tight during second-half 2007. The year-to-year decline in refinery propylene sales and coproduct propylene yields totaled 1.29 billion lb during second-half 2007.

Based on the expected decline in refinery operating rates during first-quarter 2008, refinery-grade propylene sales will decline to 3.60-3.65 billion lb, but sales will increase to 3.75-3.90 billion lb during second-quarter 2008.

Fig. 3 shows trends in coproduct and refinery merchant propylene sales.

Ethylene economics, prices

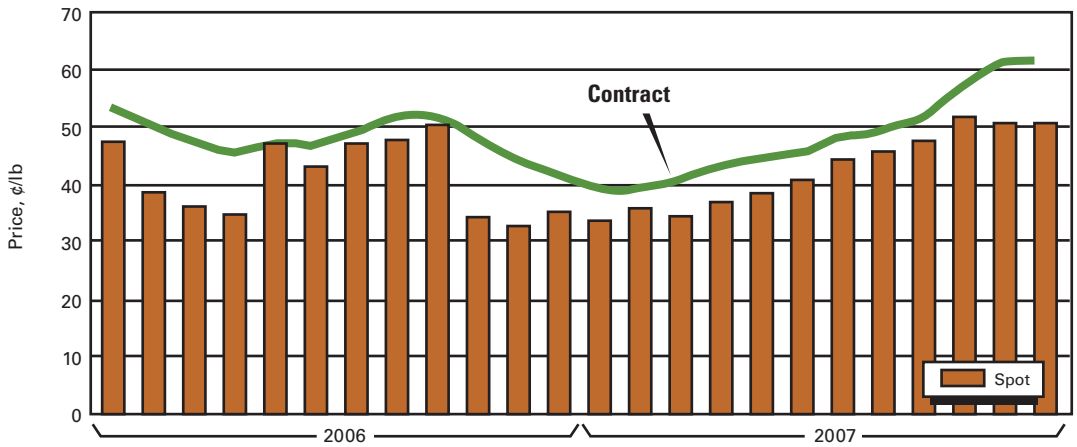
Feedstock prices, coproduct values, and ethylene plant yields determine ethylene production costs. We maintain direct contact with the olefin industry and track historic trends in spot prices for ethylene and propylene. We use a variety of sources to track trends in feedstock prices.

Some ethylene plants have the necessary process units to convert all coprod-

ucts into high-purity streams. Some ethylene plants, however, do not have the capability to upgrade mixed or crude streams of various coproducts and sell some or all their coproducts at discounted prices. We evaluate ethylene production costs in this article based on all coproducts valued at spot prices.

ETHYLENE PRICES

Fig. 4



Source: Petral market research

Ethylene production costs

Production costs for ethylene in the Houston Ship Channel (based on full spot prices for all coproducts) increased to 45-47¢/lb in December 2007 for propane and natural gasoline, which was 8-12¢/lb higher than in September. Average production costs for fourth quarter ranged from 44-45¢/lb for propane and natural gasoline to a low of 41¢/lb for purity ethane. In response to these economic incentives, ethylene producers maintained an ethane-rich feed slate during fourth-quarter 2007.

During third-quarter 2007, spot prices for ethane increased 13.3%, but spot prices for natural gasoline increased only 1.7%. Spot prices for propane increased 8.2%. Despite the increase in spot prices, ethane remained significantly less expensive than propane and was competitive with natural gasoline and similar light naphthas.

Spot prices for all feedstocks were sharply higher during fourth-quarter 2007. Spot prices for ethane were 27.1% higher than in third-quarter 2007. In contrast to almost flat prices in the third quarter, however, spot prices for natural gasoline increased 19.7% during fourth-quarter 2007. Spot prices for propane were 23% higher in fourth-quarter 2007.

Spot prices for all major coproducts also increased during second half but spot prices for polymer-grade propylene were only 13.2% higher in fourth-quarter 2007 than in third-quarter 2007. Counter to the trend in feedstock prices, spot prices for benzene and toluene declined during fourth-quarter 2007. Spot benzene prices were 2.2% lower in fourth-quarter 2007 vs. third-quarter 2007. Spot prices for toluene were 5.3% lower in fourth-quarter 2007.

Because prices for all major ethylene coproducts lagged rising feedstock prices, variable production costs based on propane and natural gasoline increased much more than for ethane during fourth-quarter 2007. Specifically, variable production costs for natural gasoline were 41% greater in fourth-quarter 2007 than in third quarter.

Similarly, variable production costs for propane were 33% higher in fourth-quarter 2007. Variable production costs for ethane increased only 28% during fourth-quarter 2007.

Table 5 shows trends in ethylene production costs.

US REFINERY MERCHANT PROPYLENE

Table 4

2007	Sales, million lb			
	Texas	Louisiana	Other states	Total
April	451.0	424.2	347.7	1,222.9
May	538.1	463.3	349.1	1,350.5
June	510.0	443.5	329.2	1,282.8
July	475.9	437.9	340.4	1,254.1
August	491.4	442.3	351.3	1,285.0
September	481.5	432.8	357.7	1,272.0
October	444.1	483.5	324.8	1,252.5

Source: EIA Petroleum Supply Monthly

ETHYLENE COSTS, HOUSTON SHIP CHANNEL

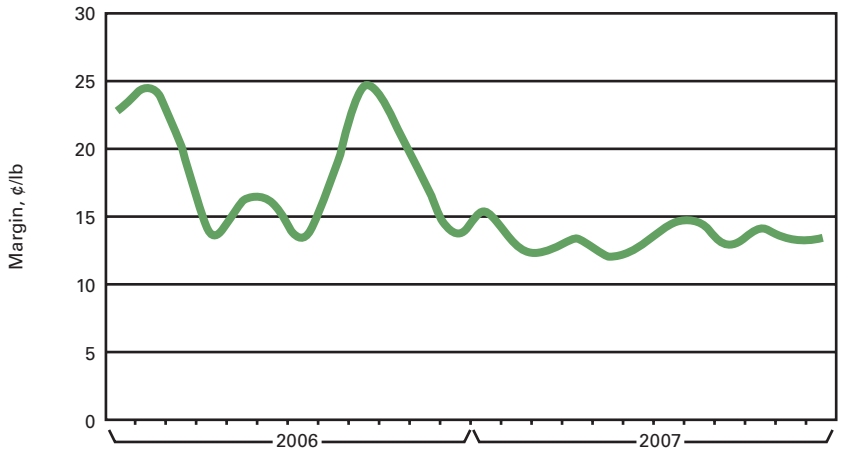
Table 5

2007	Variable, direct fixed cash costs, ¢/lb				
	Purity ethane	Purity propane	Normal butane	Natural gasoline	Industry composite
April	30.3	31.6	25.3	30.8	31.0
May	32.7	33.0	29.3	33.6	33.4
June	32.4	33.2	27.0	36.7	33.8
July	33.2	35.9	29.1	34.9	34.2
August	34.8	36.3	29.9	33.6	35.2
September	38.3	41.5	37.5	40.3	40.1
October	42.6	46.2	39.9	44.2	44.7
November	45.1	51.7	46.0	51.3	49.2
December	45.4	49.5	45.7	52.1	48.8
Forecast—2008					
January	49.6	54.1	54.3	56.0	54.8
February	51.5	58.4	57.2	57.7	57.1
March	53.5	58.8	50.2	58.7	56.5

Source: Petral production cost analysis and forecasts

ETHYLENE PROFIT MARGIN

Fig. 5



Source: Petral analysis

Ethylene prices, profit margins

Contract prices for ethylene averaged 50.2¢/lb in third-quarter 2007, which were 5.5¢/lb more than in second-quarter 2007. Contract prices increased to 52.5¢/lb in September from 48.5¢/lb in July. Contract prices jumped more sharply during fourth-quarter 2007 and averaged 60.2¢/lb, which were 10¢/lb higher than the third-quarter average.

Even though contract prices in November and December were 15.5¢/lb higher than in June, the increases just barely covered increases in production costs.

Margins based on contract prices and a feed slate of ethane, propane, and n-butane averaged 17-18¢/lb during third-quarter 2007 and 18-19¢/lb during fourth-quarter 2007. More importantly, margins based on production costs for light naphthas fell to 15-16¢/lb during fourth-quarter 2007 from 17-20¢/lb during third-quarter 2007.

During third-quarter 2007, spot prices for ethylene fluctuated within a range of 44 to 48¢/lb and averaged 46¢/lb, which was 5.2¢/lb more than in second-quarter 2007.

The increase in spot ethylene prices during third-quarter 2007 was sufficient to expand margins. Margins based on spot prices and average variable production costs increased to 12-16¢/lb during third quarter for purity ethane and light naphthas.

Spot prices for ethylene increased to 50-52¢/lb in fourth quarter but margins based on average variable production costs did not keep pace with the steady increases in feedstock prices. Margins for purity ethane were in the range of 8-12¢/lb during fourth-quarter 2007 and averaged about 10¢/lb, which was 4¢/lb less than in third-quarter 2007.

The squeeze on margins for light naphthas and natural gasoline was more severe. Margins fell to 4-5¢/lb during November and December, and averaged about 7¢/lb in fourth-quarter 2007, which was 7-8¢/lb less than during third-quarter 2007.

Figs. 4 and 5 show historic trends in ethylene prices (spot and net transaction prices) and profit margins based on composite production costs.

Octane value, propylene price

We determine octane's incremental value using the differential between unleaded premium and unleaded regular gasoline prices divided by the difference in octane (87 octane for unleaded regular gasoline and 93 octane for unleaded premium gasoline).

Octane values are a primary economic influence on spot prices for refinery-grade propylene and toluene. Trends in spot prices for these two products tend to influence prices for other coproducts.

Incremental octane values were at their peak for 2007 during third quarter and averaged 2.52¢/octane-gal vs. 2.25¢/octane-gal during second-quarter 2007. Octane values weakened during the fourth quarter and averaged 1.75¢/octane-gal. In December, octane values averaged only 1.1¢/octane-gal vs. 2.5¢/octane-gal in October.

The trend of weakening octane values was a significant factor that led to declining spot prices for toluene and benzene during fourth-quarter 2007. Weakening octane values had no effect on trends in propylene prices, however. Instead, spot prices for unleaded regular gasoline were 18¢/gal higher in fourth-quarter 2007 than in third quarter.

Spot alkylate prices track unleaded regular gasoline prices rather than declining octane values and are an important influence on refinery-grade propylene prices.

Fig. 6 shows historic trends in incremental octane values on the US Gulf Coast.

Refinery, polymer-grade $C_3^=$

Prices for all grades of propylene move in tandem with each other, and differentials between grades are generally constant within a narrow range. The premium for polymer-grade propylene covers operating costs and profit margins for the various merchant propane-propylene splitters in Texas and Louisiana.

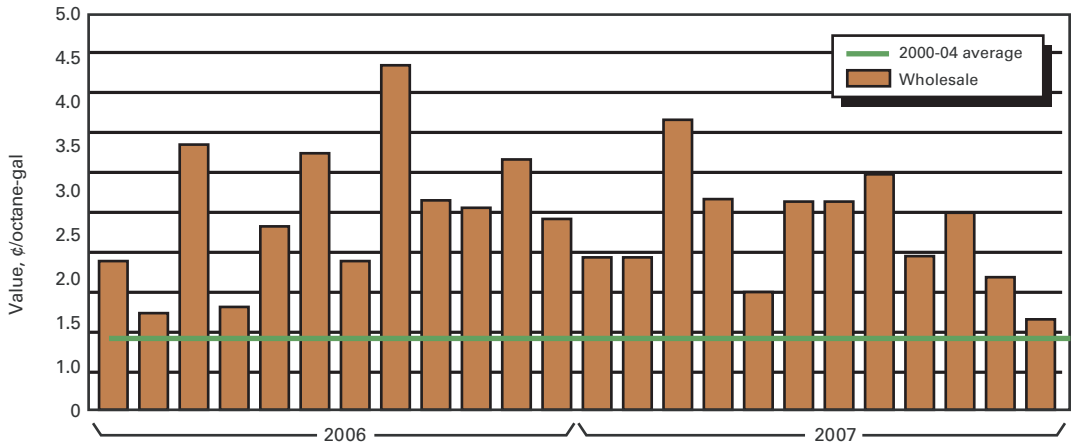
Spot prices for refinery-grade propylene were nearly constant during third-quarter 2007 and averaged 46.9¢/lb, only 0.7¢/lb more than in second-quarter 2007. Refinery-grade propylene inventories, however, as reported by the US Energy Information Administration in "This Week in Petroleum," declined to 390 million lb at the end of September from 448 million lb at the end of June.

Inventories of refinery-grade propylene continued to decline during the fourth quarter and fell to a low of only

265 million lb at the end of November. At this level, refinery-grade propylene inventories represented only 6 days of production vs. 10 days of production at the end of June. At the end of February, refinery-grade propylene inventories were 18 days of production.

US GULF COAST OCTANE VALUES

Fig. 6



Source: Petral analysis

Prices responded to tightening supply during fourth-quarter 2007 and jumped to 55-57¢/lb in November and December from 46-47¢/lb in September. Prices for refinery-grade propylene were only 7¢/lb higher than spot alkylate prices in third-quarter 2007, but the refinery-grade propylene premium widened to 11-15¢/lb during fourth-quarter 2007.

The surge in refinery-grade propylene prices during fourth-quarter 2007 helped to push prices for polymer-grade propylene sharply higher as well. Contract prices for polymer-grade propylene averaged 52.3¢/lb in third quarter, only 0.9¢/lb more than in second-quarter 2007.

While total propylene supplies continued to tighten and inventories of refinery-grade propylene fell sharply, contract prices for polymer-grade propylene increased sharply during fourth-quarter 2007. Contract prices for December settled at 62¢/lb, which were 7.75¢/lb more than in October and 10.75¢/lb more than in June.

Differentials between polymer-grade and refinery-grade propylene widened to 3.5¢/lb in third-quarter 2007 and 4.0¢/lb in fourth-quarter 2007 from 2.2¢/lb in second-quarter 2007. Trends in pricing differentials between polymer-grade and refinery-grade propylene were consistent with tightening availability for both grades.

Because nearly all of the refinery-grade propylene supply is upgraded to polymer-grade quality by merchant propane-propylene splitters, the widening differentials indicated that polymer-grade propylene experienced the brunt of the overall supply squeeze during second-half 2007.

Winter, spring 2008 outlook

During third quarter, US crude inventories declined nearly 40 million bbl. Despite the decline, crude inventories were 17 million bbl more than the average for 2004-06 and were 40 million bbl more than the average for 2002-04. Demand for crude (refinery crude inputs) averaged about 600,000 b/d less during third-quarter 2007 than year-earlier volumes.

From a purely statistical perspective, these supply-demand considerations would normally send a neutral or bearish signal to crude buyers. West Texas Intermediate prices, however, surged to $97.58/bbl during the third week of November from $70.29/bbl during the third week of August, an increase of $27.29 or 38.8%. About two-thirds of this rally in WTI prices occurred during a 7-week period from early October to mid-November.

Crude buyers and traders clearly viewed the seemingly bearish fundamentals from a radically different perspective. Despite improvement in US crude availability, global supply-demand balances remain tight with little spare production capacity available to offset any supply disruptions.

The economic outlook for olefin producers for first-half 2008 began with prices for two important crude benchmarks (WTI and Brent) flirting with the $100/bbl barrier. Acknowledging that EIA and other sources remain focused on "seemingly bearish fundamental considerations," our crude price forecast focuses on evidence that the bullish trend remains intact.

First, crude buyers reacted very bullishly in October to Turkey's decision to send troops into northern Iraq following attacks by Kurdish rebels. Until October, northern Iraq was relatively stable and had experienced relatively few disruptions, which have been commonplace in southern Iraq for the past few years.

Furthermore, escalation of tensions between Turkey and the Kurdish rebels increases the risk of disruption of crude supplies that flow through Turkey from the Caspian Sea. Tensions between the US and Iran remain high. The Bush administration, however, moved to defuse some of the tension with its most recent National Intelligence Estimate that declared that Iran was not attempting to build nuclear weapons capability.

The various threats to the flow of

crude from the Middle East will remain a significant consideration for crude buyers and traders during first-half 2008.

Finally, refiners will complete their late winter turnarounds and maintenance work by mid to late April and refinery crude demand in the US will increase 0.75-1.00 million b/d during May and June. Crude buyers and traders will anticipate this typical seasonal swing.

To accommodate the increase in US crude demand, buyers have to boost imports to 9.8-10.2 million b/d during second-quarter 2008 from 9.3-9.5 million b/d during first-quarter 2008. These seasonal swings in crude demand are bullish considerations for crude prices beginning in March and probably earlier.

Forecasts for ethylene production costs for first-half 2008 are based on WTI prices in the range of $100-110/bbl for first-quarter 2008 and $105-115/bbl during second-quarter 2008. Based on a strong seasonal increase in unleaded regular gasoline-WTI pricing differentials, regular gasoline prices in the US Gulf Coast will increase to $2.90-3.00/gal.

These forecasts set the economic basis for feedstock prices including light naphthas and propane. Ethane prices will also tend to track the general increase in feedstock prices during first-half 2008.

Ethylene production costs (full cash costs) will be 50-54¢/lb for purity ethane, 54-58¢/lb for propane, and 55-60¢/lb for natural gasoline. Rising costs will push spot and contract ethylene prices higher during first-half 2008. By April or May 2008, spot ethylene prices will increase to 65-70¢/lb and contract prices will increase to 70-75¢/lb. ✦

NELSON-FARRAR COST INDEXES

Refinery construction (1946 Basis)

(Explained on p.145 of the Dec. 30, 1985, issue)

	1962	1980	2004	2005	2006	Oct. 2006	Sept. 2007	Oct. 2007
Pumps, compressors, etc.	222.5	777.3	1,581.5	1,685.5	1,758.2	1,787.0	1,853.1	1,861.6
Electrical machinery	189.5	394.7	516.9	513.6	520.2	527.7	514.1	514.1
Internal-comb. engines	183.4	512.6	919.4	931.1	959.7	964.5	980.8	977.7
Instruments	214.8	587.3	1,087.6	1,108.0	1,166.0	1,206.5	1,282.4	1,283.5
Heat exchangers	183.6	618.7	863.8	1,072.3	1,162.7	1,179.4	1,374.7	1,374.7
Misc. equip. average	198.8	578.1	993.8	1,062.1	1,113.3	1,133.0	1,201.0	1,202.3
Materials component	205.9	629.2	1,112.7	1,179.8	1,273.5	1,319.4	1,357.7	1,350.6
Labor component	258.8	951.9	2,314.2	2,411.6	2,497.8	2,547.9	2,628.7	2,645.8
Refinery (Inflation) Index	237.6	822.8	1,833.6	1,918.8	2,008.1	2,056.5	2,120.3	2,127.7

Refinery operating (1956 Basis)

(Explained on p.145 of the Dec. 30, 1985, issue)

	1962	1980	2004	2005	2006	Oct. 2006	Sept. 2007	Oct. 2007
Fuel cost	100.9	810.5	971.9	1,360.2	1,569.0	1,434.7	1,264.3	1,374.7
Labor cost	93.9	200.5	191.8	201.9	204.2	219.2	220.5	201.4
Wages	123.9	439.9	984.0	1,007.4	1,015.4	1,060.3	1,061.4	958.6
Productivity	131.8	226.3	513.3	501.1	497.5	483.8	481.3	476.1
Invest., maint., etc.	121.7	324.8	686.7	716.0	743.7	761.7	782.4	785.1
Chemical costs	96.7	229.2	268.2	310.5	365.4	370.0	388.7	392.5
Operating indexes								
Refinery	103.7	312.7	486.7	542.1	579.0	580.8	576.8	581.0
*Process units**	103.6	457.5	638.1	787.2	870.7	834.5	782.5	816.4

**Add separate index(es) for chemicals, if any are used. See current Quarterly Costimating, first issue, months of January, April, July, and October.*

These indexes are published in the first issue of each month. They are compiled by Gary Farrar, Journal Contributing Editor.

Indexes of selected individual items of equipment and materials are also published on the Costimating page in the first issue of the months of January, April, July, and October.

The author

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Tanker earnings continue slide

Christopher E. Smith
Pipeline Editor

Tanker market earnings for the half-year ended September 2007 softened 25%, from the same period a year earlier and 10% from the prior 6 months. An early upsurge at the start of the period as the US built inventories in advance of its summer driving season gave way in May to softer-than-expected demand for oil and an oversupply of tanker tonnage. Clarkson Research Services Ltd. detailed the reasons behind these market movements as well as offering forecasts of future market direction in its Autumn 2007 "Shipping Review and Outlook: A Half-Yearly Review of the Shipping Market."

According to Clarkson data, the tanker market, comprised of both modern and early-'90s VLCCs, modern Suezmax, modern Aframax, and both dirty and clean products carriers, averaged $30,620/day in earnings from September 2006 to March 2007, a 10% decrease from the $34,025/day seen March-September 2006. A 30.2% decrease in Suezmax earnings, to $36,833/day, led the downward momentum, with clean product tankers being the only segment experiencing an improvement from the previous 6 months, increasing 6.3% to $26,866 (Table 1).

TANKER EARNINGS Table 1

Vessel type	Sept. 2006-Mar. 2007 $/day	Mar.-Sept. 2007 $/day	Change, %
VLCC (modern)	53,172	45,149	–15.1
VLCC (early 1990s)	49,452	43,006	–13.0
Suezmax (modern)	52,769	36,833	–30.2
Aframax (modern)	44,060	31,190	–27.6
Products (dirty)	31,737	28,785	–9.3
Products (clean)	25,267	26,866	6.3
Weighted average	34,025	30,620	–10.0

Even with these declines, earnings remained above the costs required to build a new vessel, but barely covered the combination of capital and operating expenses, according to Clarkson.

Of greater concern, Clarkson said, was the downward trend in spot rates, which left VLCCs earning $25,000/day in October 2007, and Aframaxes, $15,000/day.

The oil tanker fleet was expected to reach 387.6 million dwt by the end of 2007, an increase of 6.8%, with another 8.4% increase forecast for 2008. The active tanker fleet for vessels over 10,000 dwt increased by 171 ships over the 6 months ending Sept. 1, 2007; 223 vessels delivered against 32 vessels scrapped. With demand remaining sluggish, Clarkson sees fundamentals as gradually moving against the tanker market.

This article will detail some of the other findings in a few of the numerous vessel categories covered twice each year by Clarkson in its Shipping Market Outlooks.

Market outlook

A combination of sluggish trade growth and rapid fleet growth shaped the tanker market for the 6 months ending Sept. 1, 2007, according to Clarkson. Clarkson cites the lack of both significant hurricanes and shipping market congestion as increasing slack in the tanker market to a greater degree than has been seen in several years.

Crude tankers of all categories lost ground against 10-year average spot rates over the six months. The spot rate for 30,000 dwt clean product tankers also decreased to $17,765/day from $31,737/day in the preceding 6 months. Rates for a 1-year time-charter of the same vessel type, however, slipped just 2%, to $23,000/day, according to Clarkson.

Ship values, by contrast, continued to increase, with the value of 5-year old Suezmax tankers reaching $95 million from $82 million at the end of 2006.

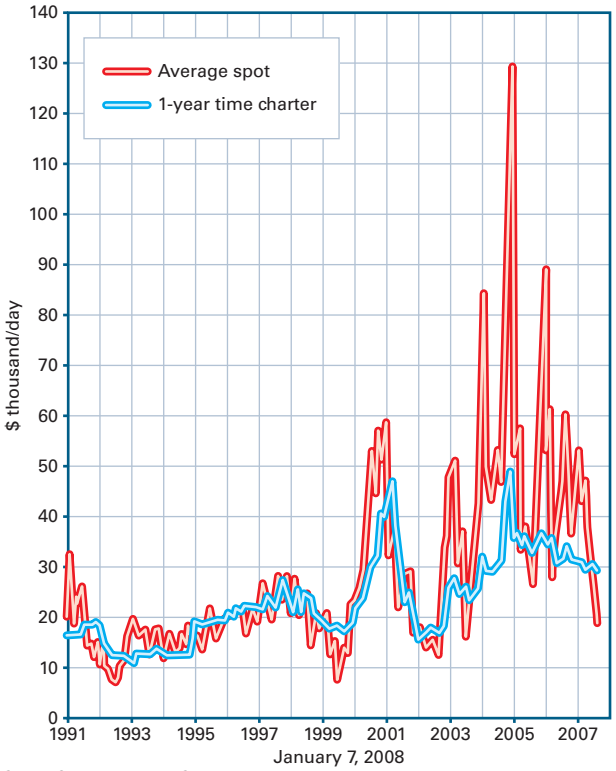
The tanker order book stands at 40% of the current fleet, but Clarkson balances the bearish implications of this building rate by noting that 24% of the fleet consists of single-hulled vessels which will need to be phased out by 2015.

VLCC

On Sept. 1, 2007, the VLCC fleet totalled 148.2 million dwt. The fleet is expected to grow by a further 2.1 million dwt by the end of 2007. Lower scrapping levels and increased deliveries in 2008 will see the fleet reach 160.9

SUEZMAX RATES, EARLY-1990S BUILT

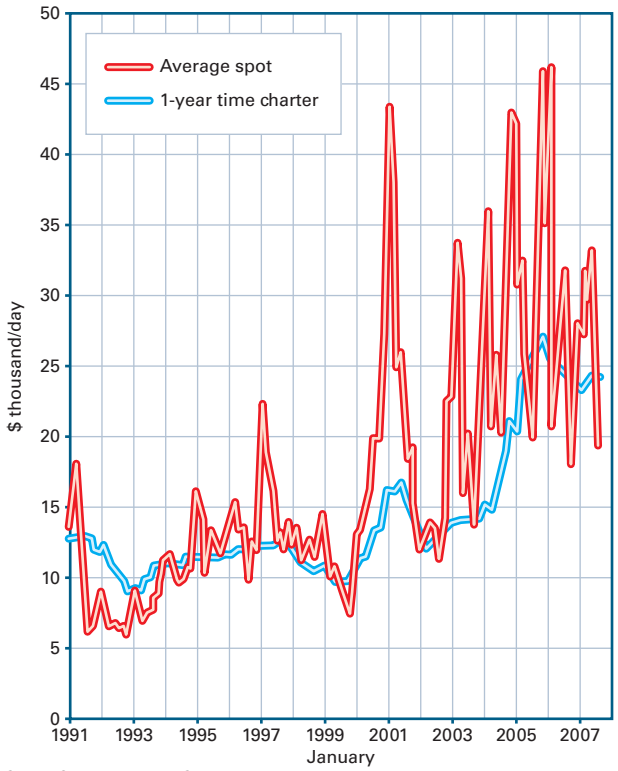
Fig. 1



Source: Clarkson Research Services.

CLEAN PRODUCT RATES

Fig. 2



Source: Clarkson Research Services.

million dwt by the end of the year, according to Clarkson. Even larger increases are anticipated for 2009, when 20.1 million tonnes will be added to the fleet. Clarkson anticipates a total 2009 fleet size of 180 million tonnes, based on just one or two vessels being scrapped each year.

Clarkson described the VLCC sector as disappointing for the 6 months ending Sept. 1, 2007, with average earnings for a 1990s-build vessel plunging to $47,993/day, compared to an average of $62,193/day for the same period 1 year earlier. This coincided with rapid fleet growth, but also, more surprisingly, with a continued increase in asset values (Table 2).

Weakness also continued in the time charter market, with 1-year rates for modern tonnage dropping to $40,000/day in September 2007 from $44,000/day at the end of 2006.

VLCC MARKET SUMMARY

Table 2

	End 2006	Sept. 2007	Change, %
	World scale rates		
AG-West	55	43	–22.7
AG-Far East	60	53	–12.5
Med-UK	105	55	–47.6
	Revenue $/day		
Average spot earnings, 1990s built	39,147	23,212	–40.7
1-year time-charter rate, 1990s built	44,000	40,000	–9.1
	Asset values Million $		
Newbuild price, 300,000 dwt	129	140	8.5
5-year old, 300,000 dwt	118	134	13.6
	Tonnage supply Million dwt		
Fleet	142.3	148.2	4.1
Orderbook	53.3	53.3	—

Clarkson sees the buildup of tonnage in this environment as a long-term bearish factor, even as short-term rates are expected to rebound as colder temperatures boost winter heating demand.

Suezmax

On Sept. 1, 2007, the Suezmax fleet consisted of 358 vessels of 54.2 million dwt. A combination of minimal scrapping and strong deliveries will see the fleet reach 57.5 million dwt by the end of 2008, according to Clarkson.

Spot rates for the 6 months ending Sept. 1, 2007, averaged $38,304/day, down 21.7% from the same period a year before, while earnings of $36,833 were down 30.2% from the previous 6 months. Time-charter rates for 1-year on a modern vessel dropped 9.7% from the end of 2006, while 3-year rates fell by 4.2% to $23,000/day (Fig. 1).

Clarkson expects spot rates in the Suezmax sector to mirror those of VLCCs over both the short and long term, with near-term demand buoying rates and a 40%-of-fleet order book potentially dampening them moving forward.

Aframax

On Sept. 1, 2007, the Aframax fleet

had increased to 75.4 million dwt. A decreased scrapping rate and increased deliveries will grow the fleet to 83 million dwt by the end of 2008, according to Clarkson.

Aframax earnings fell to $32,984 during the 6 months ending Sept. 1, 2007. Time charter rates slipped 10.4%, reaching $21,500/day for a 1-year period.

Clarkson sees the 41%-of-fleet order book in the Aframax sector as leading to the same potential medium-term oversupply of vessels expected in VLCC and Suezmax vessels, noting that this could be heightened by the potential slowdown in Bosphorus traffic as planned pipeline projects in the region enter service.

Products

Clarkson expects product rates to rebound as the northern-hemisphere winter progresses. Spot rates for clean product tankers slipped below their 10-year average, falling to $17,765/day by Sept. 1, 2007. End-2006 clean rates stood at $30,685/day (Fig. 2).

Even so, average earnings for dirty products carriers rose 4% year-on-year, with an even bigger increase of 8.5%, seen in the clean market.

On Sept. 1, 2007, the 10,000-80,000 dwt product tanker market stood at 81.2 million dwt, a 6% increase. With a 39.1 million dwt order book, the vast majority of which is due for delivery in the next 3-4 years, Clarkson expects continued rapid fleet expansion barring a large increase in the scrapping rate.

Clarkson also expects an incremental increase in the average size of the fleet.

Over the longer term, Clarkson pegs the commercial prospects for the products fleet on whether or not product demand increases year-on-year at a rate sufficient to absorb the extra tonnage.

Chemical

Sept. 1, 2007, saw spot freight rates for most chemical tanker routes having slipped below end-2006, according to Clarkson. Rates for 5,000 tonnes Rotterdam-Houston fell 20%, with Houston-Far East rates decreasing 18.2%. Rates from Houston to Rotterdam for 5,000 tonnes fell 16.4%.

Persian Gulf-Mediterranean rates were the only rates along a major route moving against this trend, rising 0.9% (15,000 tonnes). Strong Iranian methanol exports in the second quarter of 2007 keyed this strength, while Clarkson ascribed the overall softness to increased US ethanol production and midyear energy shortages in South America.

As with the other tanker segments, Clarkson sees 2008 fleet development in chemicals as hinging on the market's ability to absorb a large number of scheduled deliveries.

LNG

Clarkson described the 18 months ending Sept. 1, 2007, as having slowed somewhat in terms of new orders as compared to the pace seen over the past 10 years; final investment decisions on new liquefaction facilities having been delayed globally. Contracts for 19 vessels had been issued by Sept.1, with many slots open for 2010 delivery due to the slow in liquefaction investment. In total, 56 vessels are scheduled for delivery in 2008 and 43 in 2009. Any orders for newly approved projects will be delivered from 2011 onwards.

Prospects for major growth longer term, according to Clarkson, depend on how successful Russian and Iranian development plans end up being. Both countries have more than 30 million tonnes/year of liquefaction planned for introduction by 2014, but have political as well as the more typical economic and technical hurdles to cross before these come to fruition, says Clarkson.

Charter rates in the medium term look relatively bleak, according to Clarkson, the combination of project delays and vessel deliveries likely leading to surpluses starting in 2011 and lasting several years. ✦

Equipment/Software/Literature

New lithium cell suited for downhole use

The patent-pending MR125DD is a new primary lithium cell suited for oil and gas measurement-while-drilling (MWD) applications.

It is rated to a maximum temperature of 150° C. but operates most effectively between 75° and 125° C. The cell is an addition to the Moderate Rate family of products and is available in "DD" form factor.

For those users who cannot specifically affirm a maximum operating temperature, this firm's DDMR150 cell, rated to 150° C., is available. The company says the 150's lithium thionyl chloride chemistry offers great capacity when operating in the upper temperature range of 125° to 150° C. However, for those applications operating below 125° C., this new cell technology is suitable.

The 125° C. cell provides 33% more capacity in conditions below 125° C. at higher discharge rates than traditional industry standard lithium cells rated to 150° C., the company says. In addition, the MR125DD has greater retained capacity after prolonged exposure at higher temperatures, the firm points out. Although optimal between 75° and 125° C., this new product will operate safely in conditions up to 150° C. The 125° C. cell also delivers exceptional pulse characteristics, the firm notes. This new cell is suited for an array of oil and gas applications including MWD, logging-while-drilling, and pressure measurement.

Source: **Electrochem Commercial Power Inc.,** 9645 Wehrle Drive, Clarence, NY 14031.

Flow computer measures gas, liquids

The AutoEXEC multirun flow computer and remote telemetry unit now integrates measurement and control functionality for natural gas and petroleum liquids applications.

The AutoEXEC enables users to standardize and consolidate measurement applications on as many as 32 runs with one unit. It provides the speed and accuracy required for a number of applications, including custody transfer, the firm notes.

The unit has an update rate of 10 times per second and incorporates built-in API Ch 21.2 compliance for electronic liquid flow measurement along with API Ch 21.1 compliance for electronic gas flow measurement. In addition, the unit is easy to install with no required programming, and it is simple to operate and secure with assigned user access levels for retrieval of stored or polled data.

Built on a high performance 32-bit processor, the AutoEXEC runs at more than 300 million instructions per second while consuming minimal power. Scalable input-output gives users the flexibility to build a customized system.

USB connectivity enables users to connect a flash drive, laptop, PC, or printer. NEMA 4X enclosure enables installation onshore or offshore.

Source: **Thermo Fisher Scientific Inc.,** 81 Wyman St., Waltham, MA 02454.

Services/Suppliers

Baker Hughes Inc.

Houston, has appointed Nelson Ney president of its Centrilift division and a Baker Hughes Inc. vice-president. He succeeds Charles S. Wolley, who is leaving the company. Ney has served as operations vice-president for Hughes Christensen's Europe, Africa, Russia, and Caspian region since November 2006. Prior to that post, he served as operations vice-president for Centrilift's Latin America region and in a variety of operations, technical, and management positions with Centrilift and Hughes Christensen in Latin America. Ney joined Baker Hughes as marketing managing in Colombia in 1991. Prior to that, he was an operations engineer for Occidental Petroleum Corp. in Colombia. Ney has a bachelor's in petroleum engineering from the University of Tulsa.

Baker Hughes is a leading global provider of drilling, formation evaluation, completion, and production products and services to the oil and natural gas industry.

Geotrace

Houston, has named Steve Svatek to its technical implementation and production testing group. He will focus on the Geotrace Diamond project—a new software platform that processes and integrates all exploration and production data types and formats. With 35 years of experience in the oil and gas industry, Svatek previously worked for Hydro/Spinnaker as an internal processor. Prior to that, he worked for Nu-Tec Inc., Vastar Resources Inc., and ARCO.

Geotrace is a leading reservoir services company providing integrated solutions to the worldwide oil and gas industry.

Knight

Lafayette, La., has named Mike Brady director of human resources. Previously, he was human resources district manager for Wal-Mart in West Texas. Brady's human resources management career began in the recruiting and training side of the industry. He holds undergraduate and master's degrees in education administration and supervision from the University of Louisiana-Monroe and is currently pursuing an MBA.

Brady

Knight also has opened a new fishing facility in Alice, Tex., serving the South Texas region, and has named Doug Freeman fishing services manager at Alice. In addition, Knight has appointed Rickey Tauzin Gulf Coast regional sales manager, covering South Texas, East Texas, and Louisiana. Tauzin will be based in Houston. And Knight has named Richard Moak South Texas sales manager for oil tools and fishing services accounts in San Antonio, Austin, and Corpus Christi. Moak will be based in San Antonio.

Knight's operating units include Knight Oil Tools, Knight Fishing Services, Knight Well Services, and Knight Manufacturing. The company is the largest privately held rental tool business in the oil and gas industry.

Imports of crude and products

	Districts 1-4 1-18 2008	Districts 1-4 1-11 2008	District 5 1-18 2008	District 5 1-11 2008	Total US 1-18 2008	Total US 1-11 2008	Total US *1-19 2007
	1,000 b/d						
Total motor gasoline	1,228	938	—	—	1,228	938	991
Mo. gas. blending comp.	826	501	—	—	826	501	612
Distillate	204	290	38	19	242	309	436
Residual	576	215	—	—	576	215	357
Jet fuel-kerosine	45	85	11	—	56	85	196
Propane-propylene	222	186	44	27	266	213	189
Other	400	774	4	114	404	888	723
Total products	**3,501**	**2,989**	**97**	**160**	**3,598**	**3,149**	**3,424**
Total crude	**9,088**	**9,189**	**1,068**	**1,200**	**10,156**	**10,389**	**9,808**
Total imports	**12,589**	**12,178**	**1,165**	**1,360**	**13,754**	**13,538**	**13,232**

*Revised.
Source: US Energy Information Administration
Data available in OGJ Online Research Center.

Purvin & Gertz LNG netbacks—Jan. 25, 2008

Receiving terminal	Liquefaction plant: Algeria	Malaysia	Nigeria	Austr. NW Shelf	Qatar	Trinidad
	$/MMbtu					
Barcelona	7.17	4.98	6.30	5.43	5.62	6.22
Everett	6.65	4.37	6.25	4.44	4.99	6.96
Isle of Grain	8.50	6.15	7.88	6.03	6.79	7.82
Lake Charles	5.52	3.42	5.27	3.61	3.91	6.21
Sodegaura	6.59	8.42	6.84	8.66	7.90	5.85
Zeebrugge	7.48	5.40	6.85	5.29	5.98	6.84

Definitions, see OGJ Apr. 9, 2007, p. 57.
Source: Purvin & Gertz Inc.
Data available in OGJ Online Research Center.

Crude and product stocks

District	Crude oil	Motor gasoline: Total	Motor gasoline: Blending comp.[1]	Jet fuel, kerosine	Fuel oils: Distillate	Fuel oils: Residual	Propane-propylene
	1,000 bbl						
PADD 1	14,676	61,807	32,089	8,378	50,347	16,043	4,192
PADD 2	62,424	51,805	17,579	8,258	29,666	1,155	16,852
PADD 3	146,469	64,664	29,936	12,225	29,933	15,428	22,494
PADD 4	13,201	6,607	1,876	511	3,143	437	[1]1,911
PADD 5	52,627	35,458	27,798	10,380	15,454	5,477	—
Jan. 18, 2008	**289,397**	**220,341**	**109,278**	**39,752**	**128,543**	**38,540**	**45,449**
Jan. 11, 2008	**287,100**	**215,256**	**106,183**	**40,052**	**129,845**	**37,902**	**48,668**
Jan. 19, 2007[2]	**322,243**	**220,795**	**98,125**	**40,203**	**142,625**	**45,611**	**53,557**

[1]Includes PADD 5. [2]Revised.
Source: US Energy Information Administration
Data available in OGJ Online Research Center.

Refinery report—Jan. 18, 2008

District	Refinery operations: Gross inputs	Refinery operations: Crude oil inputs	Refinery output: Total motor gasoline	Refinery output: Jet fuel, kerosine	Refinery output: Fuel oils: Distillate	Refinery output: Fuel oils: Residual	Refinery output: Propane-propylene
	1,000 b/d		1,000 b/d				
PADD 1	1,425	1,424	1,688	100	522	125	62
PADD 2	3,265	3,236	2,303	193	955	53	206
PADD 3	7,099	7,038	3,206	698	1,939	360	668
PADD 4	534	536	331	26	162	19	[1]136
PADD 5	2,759	2,686	1,437	431	526	150	—
Jan. 18, 2008	**15,082**	**14,920**	**8,965**	**1,448**	**4,104**	**707**	**1,072**
Jan. 11, 2008	**15,187**	**15,011**	**8,978**	**1,580**	**4,257**	**645**	**1,114**
Jan. 19, 2007[2]	**15,202**	**14,896**	**9,106**	**1,442**	**3,948**	**598**	**1,031**
	17,436 operable capacity		**86.5% utilization rate**				

[1]Includes PADD 5. [2]Revised.
Source: US Energy Information Administration
Data available in OGJ Online Research Center.

Additional analysis of market trends is available through **OGJ Online**, *Oil & Gas Journal's* electronic information source, at http://www.ogjonline.com.

OIL&GAS JOURNAL online research center

OGJ crack spread

	*1-25-08	*1-26-07	Change $/bbl	Change, %
SPOT PRICES				
Product value	98.24	61.40	36.85	60.0
Brent crude	90.05	54.46	35.59	65.4
Crack spread	8.19	6.94	1.25	18.1
FUTURES MARKET PRICES				
One month				
Product value	99.08	62.59	36.49	58.3
Light sweet crude	89.24	54.24	35.00	64.5
Crack spread	9.84	8.35	1.49	17.8
Six month				
Product value	101.67	69.62	32.05	46.0
Light sweet crude	87.53	57.73	29.80	51.6
Crack spread	14.14	11.88	2.26	19.0

*Average for week ending.
Source: Oil & Gas Journal
Data available in OGJ Online Research Center.

OGJ GASOLINE PRICES

	Price ex tax 1-23-08	Pump price* 1-23-08	Pump price 1-24-07
	¢/gal		
(Approx. prices for self-service unleaded gasoline)			
Atlanta	272.0	311.7	220.2
Baltimore	267.7	309.6	224.1
Boston	270.7	312.6	226.2
Buffalo	261.5	321.6	245.1
Miami	269.4	319.7	233.3
Newark	275.6	308.5	219.2
New York	251.5	311.6	233.0
Norfolk	277.9	215.5	214.2
Philadelphia	258.0	308.7	248.0
Pittsburgh	260.9	311.6	230.2
Wash., DC	271.2	309.6	235.0
PAD I avg.	266.9	312.8	229.9
Chicago	294.5	345.4	226.3
Cleveland	257.3	303.7	210.3
Des Moines	260.2	300.6	205.5
Detroit	253.3	302.5	203.7
Indianapolis	258.7	303.7	202.9
Kansas City	255.6	291.6	201.3
Louisville	263.7	300.6	207.6
Memphis	261.8	301.6	212.2
Milwaukee	252.3	303.6	219.4
Minn.-St. Paul	260.2	300.6	203.6
Oklahoma City	242.6	278.0	195.5
Omaha	241.9	288.3	208.5
St. Louis	264.6	300.6	203.5
Tulsa	258.9	294.3	202.2
Wichita	245.3	288.7	198.6
PAD II avg.	258.1	300.3	206.8
Albuquerque	262.3	298.7	212.2
Birmingham	253.0	291.7	215.2
Dallas-Fort Worth	248.3	286.7	217.2
Houston	249.3	287.7	209.1
Little Rock	251.5	291.7	213.2
New Orleans	262.3	300.7	216.1
San Antonio	251.2	289.6	213.1
PAD III avg.	254.0	292.4	213.8
Cheyenne	252.3	284.7	205.2
Denver	255.4	295.8	212.6
Salt Lake City	249.4	292.3	224.0
PAD IV avg.	252.5	290.9	213.9
Los Angeles	272.3	330.8	256.5
Phoenix	253.9	291.3	235.9
Portland	269.0	312.3	266.0
San Diego	277.7	336.2	267.0
San Francisco	292.7	351.2	269.6
Seattle	266.8	319.2	267.5
PAD V avg.	272.0	323.5	260.4
Week's avg.	**261.3**	**304.9**	**222.2**
Dec. avg.	**257.0**	**300.6**	**228.5**
Nov. avg.	**264.0**	**307.6**	**223.7**
2008 to date	**261.9**	**305.5**	—
2007 to date	**182.6**	**226.2**	—

*Includes state and federal motor fuel taxes and state sales tax. Local governments may impose additional taxes.
Source: Oil & Gas Journal.
Data available in OGJ Online Research Center.

REFINED PRODUCT PRICES

	1-18-08 ¢/gal		1-18-08 ¢/gal
Spot market product prices			
Motor gasoline (Conventional-regular)		Heating oil No. 2	
New York Harbor	227.75	New York Harbor	250.29
Gulf Coast	225.25	Gulf Coast	244.31
Los Angeles	203.25	Gas oil	
Amsterdam-Rotterdam-Antwerp (ARA)	213.87	ARA	249.98
Singapore	229.12	Singapore	247.98
Motor gasoline (Reformulated-regular)		Residual fuel oil	
New York Harbor	226.75	New York Harbor	172.93
Gulf Coast	225.75	Gulf Coast	169.36
Los Angeles	208.25	Los Angeles	175.26
		ARA	184.85
		Singapore	168.70

Source: DOE Weekly Petroleum Status Report.
Data available in OGJ Online Research Center.

BAKER HUGHES RIG COUNT

	1-25-08	1-26-07
Alabama	3	3
Alaska	7	9
Arkansas	46	38
California	37	33
Land	36	31
Offshore	1	2
Colorado	102	99
Florida	0	0
Illinois	0	0
Indiana	1	1
Kansas	13	15
Kentucky	9	10
Louisiana	148	174
N. Land	53	49
S. Inland waters	21	12
S. Land	26	45
Offshore	48	68
Maryland	1	0
Michigan	1	1
Mississippi	10	16
Montana	12	16
Nebraska	0	0
New Mexico	71	85
New York	4	9
North Dakota	49	31
Ohio	11	12
Oklahoma	195	168
Pennsylvania	18	14
South Dakota	1	0
Texas	851	796
Offshore	8	12
Inland waters	5	1
Dist. 1	16	19
Dist. 2	30	25
Dist. 3	66	52
Dist. 4	86	96
Dist. 5	187	150
Dist. 6	122	129
Dist. 7B	30	31
Dist. 7C	46	48
Dist. 8	128	101
Dist. 8A	18	30
Dist. 9	38	36
Dist. 10	71	66
Utah	39	45
West Virginia	32	32
Wyoming	74	83
Others—NV-3; TN-6; VA-3	12	9
Total US	**1,747**	**1,699**
Total Canada	**582**	**664**
Grand total	**2,329**	**2,363**
Oil rigs	318	255
Gas rigs	1,422	1,440
Total offshore	57	83
Total cum. avg. YTD	**1,749**	**1,714**

Rotary rigs from spudding in to total depth.
Definitions, see OGJ Sept. 18, 2006, p. 42.

Source: Baker Hughes Inc.
Data available in OGJ Online Research Center.

SMITH RIG COUNT

Proposed depth, ft	Rig count	1-25-08 Percent footage*	Rig count	1-26-07 Percent footage*
0-2,500	62	4.8	57	—
2,501-5,000	100	50.0	100	51.0
5,001-7,500	229	26.6	223	25.1
7,501-10,000	425	2.1	419	3.3
10,001-12,500	427	4.2	405	1.9
12,501-15,000	310	0.3	248	0.4
15,001-17,500	102	—	123	1.6
17,501-20,000	71	—	72	—
20,001-over	32	—	41	—
Total	**1,758**	**8.0**	**1,688**	**7.8**
INLAND	37		32	
LAND	1,670		1,593	
OFFSHORE	51		63	

*Rigs employed under footage contracts.
Definitions, see OGJ, Sept. 18, 2006, p. 42.

Source: Smith International Inc.
Data available in OGJ Online Research Center.

OGJ PRODUCTION REPORT

	[1]1-25-08	[2]1-26-07
	1,000 b/d	
(Crude oil and lease condensate)		
Alabama	14	19
Alaska	660	779
California	645	675
Colorado	48	58
Florida	5	6
Illinois	27	26
Kansas	90	94
Louisiana	1,363	1,340
Michigan	16	15
Mississippi	47	49
Montana	94	98
New Mexico	171	164
North Dakota	107	115
Oklahoma	165	170
Texas	1,349	1,321
Utah	42	51
Wyoming	144	146
All others	61	69
Total	**5,048**	**5,195**

[1]OGJ estimate. [2]Revised.

Source: Oil & Gas Journal.
Data available in OGJ Online Research Center.

US CRUDE PRICES

$/bbl*	1-25-08
Alaska-North Slope 27°	87.07
South Louisiana Sweet	94.00
California-Kern River 13°	78.05
Lost Hills 30°	86.50
Southwest Wyoming Sweet	82.21
East Texas Sweet	86.75
West Texas Sour 34°	80.00
West Texas Intermediate	87.50
Oklahoma Sweet	87.50
Texas Upper Gulf Coast	84.00
Michigan Sour	80.50
Kansas Common	86.25
North Dakota Sweet	82.50

*Current major refiner's posted prices except North Slope lags 2 months. 40° gravity crude unless differing gravity is shown.

Source: Oil & Gas Journal.
Data available in OGJ Online Research Center.

WORLD CRUDE PRICES

$/bbl[1]	1-18-08
United Kingdom-Brent 38°	91.96
Russia-Urals 32°	87.84
Saudi Light 34°	88.05
Dubai Fateh 32°	86.87
Algeria Saharan 44°	92.15
Nigeria-Bonny Light 37°	92.55
Indonesia-Minas 34°	95.03
Venezuela-Tia Juana Light 31°	87.17
Mexico-Isthmus 33°	87.06
OPEC basket	89.84
Total OPEC[2]	88.21
Total non-OPEC[2]	88.14
Total world[2]	88.18
US imports[3]	85.36

[1]Estimated contract prices. [2]Average price (FOB) weighted by estimated export volume. [3]Average price (FOB) weighted by estimated import volume. Source: DOE Weekly Petroleum Status Report.
Data available in OGJ Online Research Center.

US NATURAL GAS STORAGE[1]

	1-18-08	1-11-08	1-18-07	Change, %
	bcf			
Producing region	809	858	861	–6.0
Consuming region east	1,402	1,482	1,596	–12.2
Consuming region west	325	351	326	–0.3
Total US	**2,536**	**2,691**	**2,783**	**–8.9**
	Oct. 07	**Oct. 06**	**Change, %**	
Total US[2]	**3,567**	**3,452**	**3.3**	

[1]Working gas. [2]At end of period.
Source: Energy Information Administration.
Data available in OGJ Online Research Center.

PACE REFINING MARGINS

	Nov. 2007	Dec. 2007	Jan. 2008	Jan. 2007	2007 vs. 2006 Change	2007 vs. 2006 Change, %
	$/bbl					
US Gulf Coast						
West Texas Sour	12.27	9.53	9.04	9.45	–0.42	–4.5
Composite US Gulf Refinery	13.14	13.01	11.34	9.97	1.37	13.7
Arabian Light	10.91	15.39	12.75	9.72	3.03	31.2
Bonny Light	5.73	3.39	5.24	2.81	2.43	86.5
US PADD II						
Chicago (WTI)	9.98	6.87	5.72	5.93	–0.21	–3.6
US East Coast						
NY Harbor (Arab Med)	5.65	10.04	7.67	5.44	2.23	41.0
East Coast Comp-RFG	8.57	12.06	6.31	6.34	–0.03	–0.4
US West Coast						
Los Angeles (ANS)	12.85	12.31	5.81	17.83	–12.03	–67.4
NW Europe						
Rotterdam (Brent)	6.07	3.08	1.31	2.43	–1.12	–46.2
Mediterranean						
Italy (Urals)	10.66	8.40	7.61	7.83	–0.22	–2.9
Far East						
Singapore (Dubai)	7.44	7.00	6.25	8.48	–2.20	–26.0

Source: Jacobs Consultancy Inc.
Data available in OGJ Online Research Center.

US NATURAL GAS BALANCE DEMAND/SUPPLY SCOREBOARD

	Oct. 2007	Sept. 2007	Oct. 2006	Oct. 2007-2006 change	Total YTD 2007	Total YTD 2006	YTD 2007-2006 change
	bcf						
DEMAND							
Consumption	1,559	1,587	1,640	–41	18,793	17,776	1,017
Addition to storage	334	372	246	88	2,934	2,668	266
Exports	59	61	58	1	614	582	32
Canada	27	29	30	–3	334	249	85
Mexico	28	28	25	3	240	281	41
LNG	4	4	3	1	40	52	–12
Total demand	**1,992**	**2,020**	**1,944**	**48**	**22,341**	**21,026**	**1,315**
SUPPLY							
Production (dry gas)	1,633	1,580	1,587	46	15,764	15,372	392
Supplemental gas	4	5	6	–2	52	54	–2
Storage withdrawal	76	73	115	–39	2,433	2,668	–235
Imports	352	358	333	19	3,837	3,463	374
Canada	320	314	296	24	3,096	2,971	125
Mexico	NA	2	1	–1	18	7	11
LNG	32	42	36	–4	723	485	238
Total supply	**2,065**	**2,016**	**2,041**	**24**	**22,086**	**21,557**	**529**

NATURAL GAS IN UNDERGROUND STORAGE

	Oct. 2007	Sept. 2007	Aug. 2007	Oct. 2006	Change
	bcf				
Base gas	4,236	4,232	4,226	4,217	19
Working gas	3,567	3,316	3,017	3,452	115
Total gas	**7,803**	**7,548**	**7,243**	**7,669**	**134**

Source: DOE Monthly Energy Review.
Data available in OGJ Online Research Center. NOTE: NO NEW DATA AT PRESS TIME.

WORLDWIDE NGL PRODUCTION

	Oct. 2007	Sept. 2007	10 month average Production 2007	10 month average Production 2006	Change vs. previous year Volume,	Change vs. previous year %
	1,000 b/d					
Brazil	85	86	84	86	–2	–2.4
Canada	640	632	690	674	16	2.4
Mexico	371	372	400	435	–35	–8.0
United States	1,837	1,795	1,762	1,735	27	1.5
Venezuela	200	200	200	200	—	—
Other Western Hemisphere	209	210	205	215	–10	–4.6
Western Hemisphere	**3,341**	**3,296**	**3,341**	**3,345**	**–4**	**–0.1**
Norway	296	219	280	282	–1	–0.5
United Kingdom	154	99	139	151	–12	–7.8
Other Western Europe	10	10	10	10	—	–2.0
Western Europe	**460**	**328**	**429**	**442**	**–13**	**–3.0**
Russia	428	428	426	416	11	2.6
Other FSU	160	160	160	160	—	—
Other Eastern Europe	15	12	15	17	–3	–14.9
Eastern Europe	**602**	**600**	**601**	**593**	**8**	**1.4**
Algeria	345	340	341	306	35	11.3
Egypt	70	70	70	73	–3	–4.1
Libya	80	80	80	86	–6	–7.0
Other Africa	187	187	186	190	–4	–2.0
Africa	**682**	**677**	**677**	**655**	**22**	**3.3**
Saudi Arabia	1,427	1,427	1,427	1,427	—	—
United Arab Emirates	250	250	250	250	—	—
Other Middle East	871	871	870	904	–34	–3.7
Middle East	**2,548**	**2,548**	**2,547**	**2,581**	**–34**	**–1.3**
Australia	73	77	75	82	–7	–8.3
China	180	180	180	180	—	—
India	—	—	4	41	–38	–90.8
Other Asia-Pacific	174	172	177	185	–9	–4.7
Asia-Pacific	**427**	**429**	**436**	**489**	**–53**	**–10.9**
TOTAL WORLD	**8,061**	**7,877**	**8,032**	**8,105**	**–74**	**–0.9**

Totals may not add due to rounding.
Source: Oil & Gas Journal.
Data available in OGJ Online Research Center.

OXYGENATES

	Nov. 2007	Oct. 2007	Change	YTD 2007	YTD 2006	Change
	1,000 bbl					
Fuel ethanol						
Production	14,356	14,018	338	139,255	104,581	34,674
Stocks	11,194	11,423	–223	11,194	9,212	1,982
MTBE						
Production	1,734	1,632	102	21,024	29,195	–8,171
Stocks	1,216	1,454	–238	1,216	1,460	–244

Source: DOE Petroleum Supply Monthly.
Data available in OGJ Online Research Center.

US HEATING DEGREE-DAYS

	Dec. 2007	Dec. 2006	Normal	2007 % change from normal	Total degree-days July 1 through Dec. 31 2007	Total degree-days July 1 through Dec. 31 2006	Total degree-days July 1 through Dec. 31 Normal	% change from normal
New England	1,127	871	1,078	4.5	2,373	2,121	2,462	–3.6
Middle Atlantic	976	778	998	–2.2	1,940	1,799	2,191	–11.5
East North Central	1,116	919	1,135	–1.7	2,261	2,266	2,472	–8.5
West North Central	1,285	1,010	1,248	3.0	2,533	2,462	2,695	–6.0
South Atlantic	447	426	555	–19.5	895	969	1,083	–17.4
East South Central	569	600	715	–20.4	1,166	1,342	1,410	–17.3
West South Central	447	466	520	–14.0	783	821	905	–13.5
Mountain	979	915	928	5.5	1,930	2,035	2,147	–10.1
Pacific	616	545	563	9.4	1,222	1,123	1,253	–2.5
US average*	**790**	**683**	**817**	**–3.3**	**1,572**	**1,555**	**1,739**	**–9.6**

*Excludes Alaska and Hawaii.
Source: DOE Monthly Energy Review.
Data available in OGJ Online Research Center.

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Societe Generale mess a reminder of trading perils

The unfolding Jerome Kerviel drama says much about cap-and-trade remedies for climate change. Kerviel is the French trader of stock indexes alleged to have lost the venerable Societe Generale $7.2 billion through unauthorized transactions. The bank thinks the 31-year-old Kerviel masked his shenanigans by hacking into its computers. The unraveling of his illicit trade position, disclosed Jan. 24, may have

The Editor's Perspective

by Bob Tippee, Editor

aggravated global financial turmoil. This is not the first time bonkers trading and unvigilant accounting have rocked institutions that seemed to have their affairs under control. The names Metallgesellschaft, Barings Bank, and Enron leap to mind.

Kerviel's misadventure thus serves as a reminder, not a revelation, of regrettable truths: Where a lot of fast money can be made from the buying and selling of something, someone always tests boundaries of prudence if not law. And it's in the nature of boundary-testers to find ways around whatever controls may be in place.

To acknowledge the hazards of an economically essential activity is not to condemn trading as a practice. The hazards, though, are good reasons to be wary of trading as a tool of governance.

As governments hurl themselves toward regulation of greenhouse-gas emissions, a choice emerges between the direct taxation of carbon and the state-sponsored trading of emission allowances. Under the latter option, which the European Union has implemented for carbon dioxide, governments assign companies emission caps calibrated to national targets. Companies able to cut emissions to below permitted levels sell corresponding allowances, or credits, to above-cap emitters.

A market thus develops in tradable emission credits, a market that grows as governments lower the emission limits.

Cap-and-trade systems camouflage the inescapable costs of cutting emissions of carbon dioxide and other greenhouse gases. Direct taxation of carbon, by contrast, makes those costs clear. It encourages the prospective cost-bearers to wonder how much sacrifice they would need to make before they might realistically hope to influence global average temperature. It thus raises questions about the wisdom of governmental responses to climate change.

Because of the political expediency, governments naturally favor cap-and-trade. Can anyone guess which alternative traders, especially the rogues, might prefer?

(Online Jan. 25, 2008; author's e-mail: bobt@ogjonline.com)

Market Journal

by Sam Fletcher, Senior Writer

Government action revitalizes markets

Fears of recession and unauthorized trading at an international French bank battered equity markets, forcing government action that caused US energy prices to rebound in late January.

During Jan. 14-18, US stocks posted the steepest weekly drop since July 2002 after reports of lower-than-expected home construction, retail sales, and manufacturing numbers reinforced speculation that the economy is entering a recession. But US markets were closed for holiday Jan. 21 during a large sell-off in global markets. At first the sell-off was attributed to fears that failing credit markets could drive the US economy into recession.

But later Societe Generale said a rogue trader in its Paris office had for months made unauthorized trades that cost the bank some $7.2 billion. That prompted speculation that it was Societe Generale's attempts to close out the fraudulent trades that had rocked European markets.

Olivier Jakob, Petromatrix GMBH, Zug, Switzerland, said, "Currency markets were building some expectations that other central banks might follow in the footsteps of the US Federal Reserve, but with Societe Generale creating doubts as to what triggered the equity rout, the chance of a more coordinated action on interest rates has become more remote and the dollar index has been under pressure."

On Jan. 22, the near-month crude contract dropped to $86.11/bbl in intraday trading before climbing back to just below $90/bbl in New York as the Federal Reserve reduced its overnight lending rate by three quarters of a percentage point to 3.5%. It was the first time since Sept. 17, 2001, that the Federal Open Market Committee changed the federal funds target rate outside of a regular meeting.

"When oil comes tumbling down, the Organization of Petroleum Exporting Countries pulls an emergency cut and when the Dow Jones Industrial comes tumbling down, the Fed does the same," Jakob said. "The Fed emergency cut came coincidently at the crucial time when West Texas Intermediate was starting to test the support of the previous correction and makes...a nice double bottom at $86/bbl."

The crude futures price tumbled to a 3-month low below $87/bbl Jan. 23 as recession fears continued to flail the market. But energy futures posted the biggest gains in 3 weeks on Jan. 24 with the March crude contract jumping $2.42 to $89.41/bbl Jan. 24 on the New York Mercantile Exchange after President George W. Bush and Congressional leaders generally agreed to an economic stimulus package that will give tax rebates to most US taxpayers.

The crude contract continued climbing to finish the week at $90.71/bbl Jan. 25 on the New York market. "Markets continued to rally behind federal actions, and energy was no different," said analysts in the Houston office of Raymond James & Associates Inc.

Since the start of 2008, oil prices have fallen 10% primarily because of US economic worries. While the US comprises 30% of total oil demand, Raymond James said, "It is the developing world, particularly China, that is the key driver of today's oil demand growth."

Natural gas outlook

Meanwhile, Raymond James analysts said: "In the short run, the US has very limited, if any, ability to switch from crude to natural gas as a fuel source. This is one of several factors that have helped provide us with confidence that oil and US gas prices will not average the typical 7:1 btu parity in 2008 or even in 2009. In the long run (beyond 2010), oil and gas should eventually return to parity on a global basis. There will be many forces that will ultimately lead us back to parity. The most important and timely driver will be the build-out of a global LNG and natural gas infrastructure [that] will include regasification terminals, gas pipelines, gas storage, and gas-fired consumers in regions other than the US. For example, we just cannot imagine China being willing to pay two or three times as much (per btu) for energy than the US. The global gas build-out will happen. It is just a matter of how long it will take to accomplish."

Raymond James analysts said, "In addition to natural gas and LNG becoming a more fungible global commodity, the next decade will likely see (1) an increase in natural gas-fired electricity generation, (2) a decrease in the use of oil as a heating fuel, and (3) the ability to use natural gas as an automotive fuel source. The bottom line for investors is that we do not believe that oil and US gas prices will be linked to the typical 7:1 btu price parity ratio over the next few years.

(Online Jan. 28, 2008; author's e-mail: samf@ogjonline.com)

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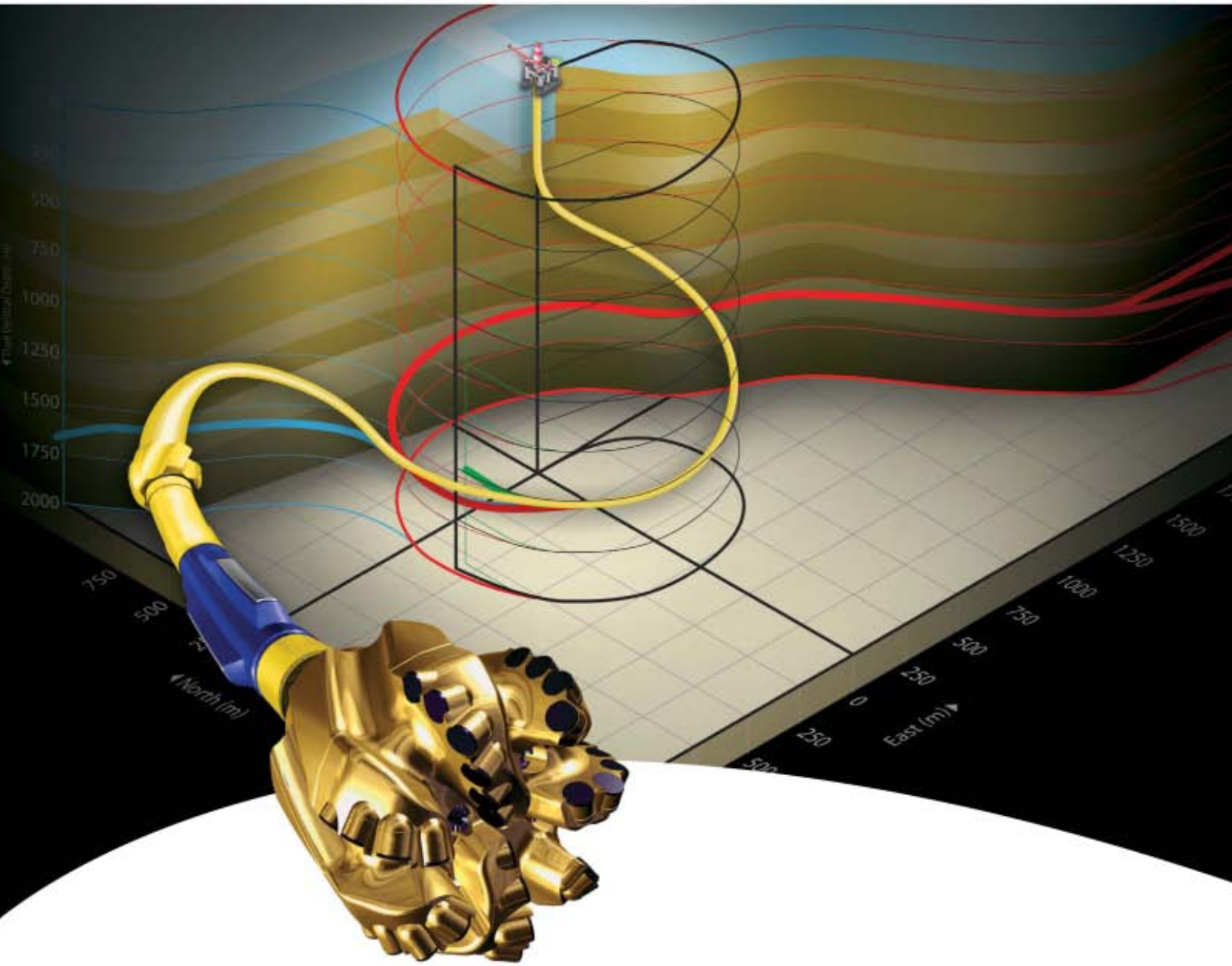

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