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LNG UPDATE

US MIDSTREAM UPDATE

MEXICO'S SHALE GAINS TRACTION

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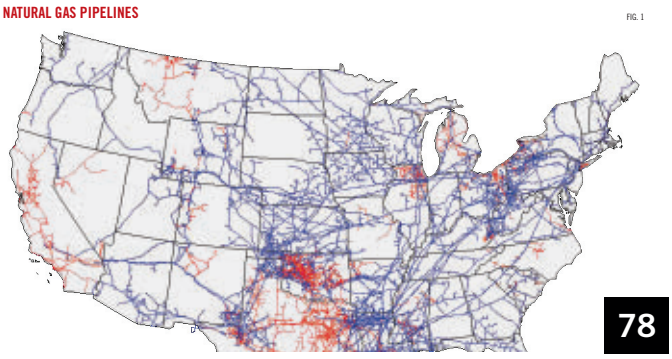
June 6, 2016 **Volume** 114.6

GENERAL INTEREST

COVER

Cheniere Energy Inc.'s *Sabine Pass LNG terminal began import operations in 2008 with 4 bcfd vaporization capacity. In third-quarter 2012 Cheniere began construction of export liquefaction capacity, loading its first cargo Feb. 24. Cheniere plans to have six 4.5 million-tonne/year liquefaction trains operational at Sabine Pass by fourth-quarter 2018. Oil & Gas Journal's LNG Update special report begins on p. 78. Photo by Cheniere Energy.*



SPECIAL REPORT
LNG UPDATE

SPECIAL REPORT
US MIDSTREAM UPDATE

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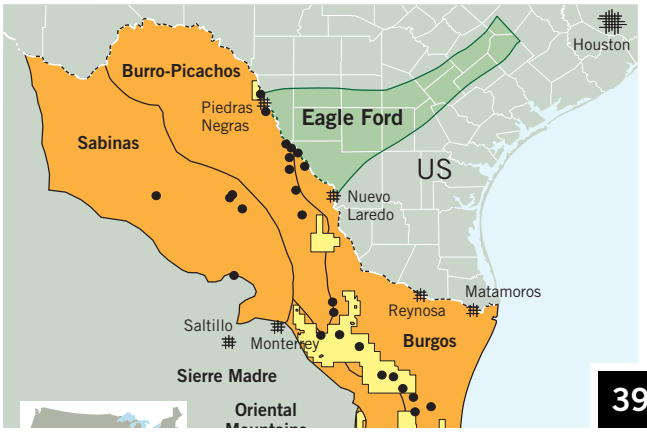
NORTHEAST MEXICO SHALE POTENTIAL

FIG. 1



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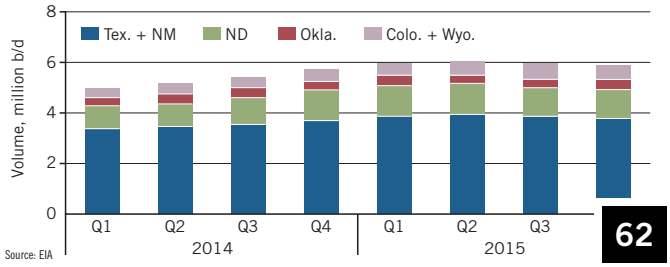
CRUDE OIL PRODUCTION, SELECTED STATES

FIG. 1



Source: EIA

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TECHNOLOGY...

EXPLORATION & DEVELOPMENT

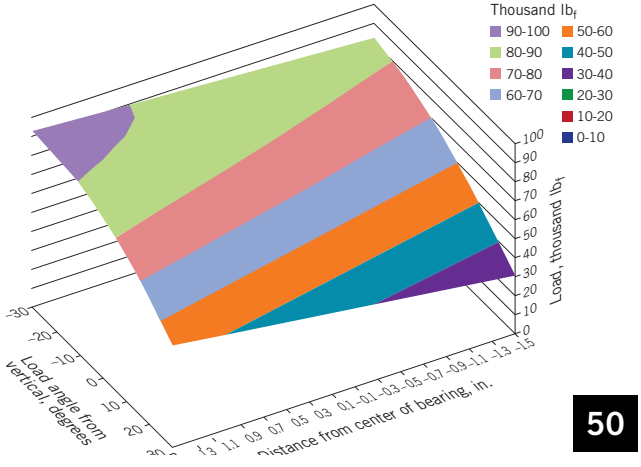
DRILLING & PRODUCTION

PROCESSING

TRANSPORTATION

MAIN-BEARING DYNAMIC EQUIVALENT RADIAL LOAD

FIG. 2



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GENERAL INTEREST QUICK TAKES

Aramco signs agreements aimed at expansion

Saudi Aramco has entered agreements aimed at expanding into offshore construction in Saudi Arabia.

The expansion follows plans announced by Saudi officials in April to make Aramco an industrial conglomerate in a program of sweeping economic reform called Saudi Vision 2030 (OGJ Online, Apr. 25, 2016).

Aramco signed a joint development agreement with National Shipping Co. of Saudi Arabia (Bahri), Lamprell of Dubai, and Hyundai Heavy Industries for a maritime yard in eastern Saudi Arabia to provide engineering, manufacturing, and repair services for offshore rigs, commercial vessels, and offshore support vessels.

The companies signed a memorandum of understanding (MOU) for the project in January and have been conducting due diligence and feasibility studies. The plant would be at Ras Al Khair.

Under the JDA they'll work on financing, construction, operation, and ownership issues and begin negotiations of definitive agreements before making a final investment decision.

Separately, Aramco signed an MOU with GE and Cividale SPA of Italy to build a forging and casting manufacturing plant for maritime and energy industries in the Middle East and North Africa. Like the maritime plant, the facility would be at Ras Al Khair.

Joint investment would be more than $400 million.

Aramco also is working with partners to develop an onshore rig manufacturing facility, an engine manufacturing project, and an energy industrial city to accelerate manufacturing industries serving the oil and gas business.

Mubadala, Oxy withdraw from Bahrain venture

Mubadala Petroleum and Occidental Petroleum Corp. have withdrawn from Tatweer Petroleum, a joint venture formed in 2009 to redevelop Bahrain oil field, according to press reports (OGJ Online, Nov. 10, 2009).

The remaining Tatweer shareholder, Nogaholding, owned by the Bahraini government, owns about half of Tatweer.

According to Mubadala Petroleum, owned by the government of Abu Dhabi, Tatweer drilled more than 780 wells and refurbished and added production equipment and gas and water-handling facilities to boost output rates to 44,400 b/d of oil and 2.3 bcfd of natural gas by yearend 2014 from 26,100 b/d of oil and 1.6 bcfd of gas when it began work.

Bahrain field, discovered in 1932, earlier was known as Awali field.

Dove to succeed Sheffield at PNR

Timothy L. Dove, president and chief operating officer of Pioneer Natural Resources Co. (PNR), Dallas, has been named president and chief executive officer of the company to succeed Scott D. Sheffield, who will retire at yearend.

Both executives worked for predecessor company Parker & Parsley Petroleum Co., which became PNR after the merger of Mesa Petroleum in 1997.

At the time of the merger, Sheffield was Parker & Parsley's chairman of the board and chief executive officer and became chief executive of the new firm. He was elected chairman in 1999.

Dove was Parker & Parsley senior vice-president at the time of the Mesa merger and held several PNR executive positions before becoming president and chief operating officer in 2004.

Sheffield will continue as executive chairman of the PNR board through 2017, when he'll retire as an executive and employee of the company but remain on the board.

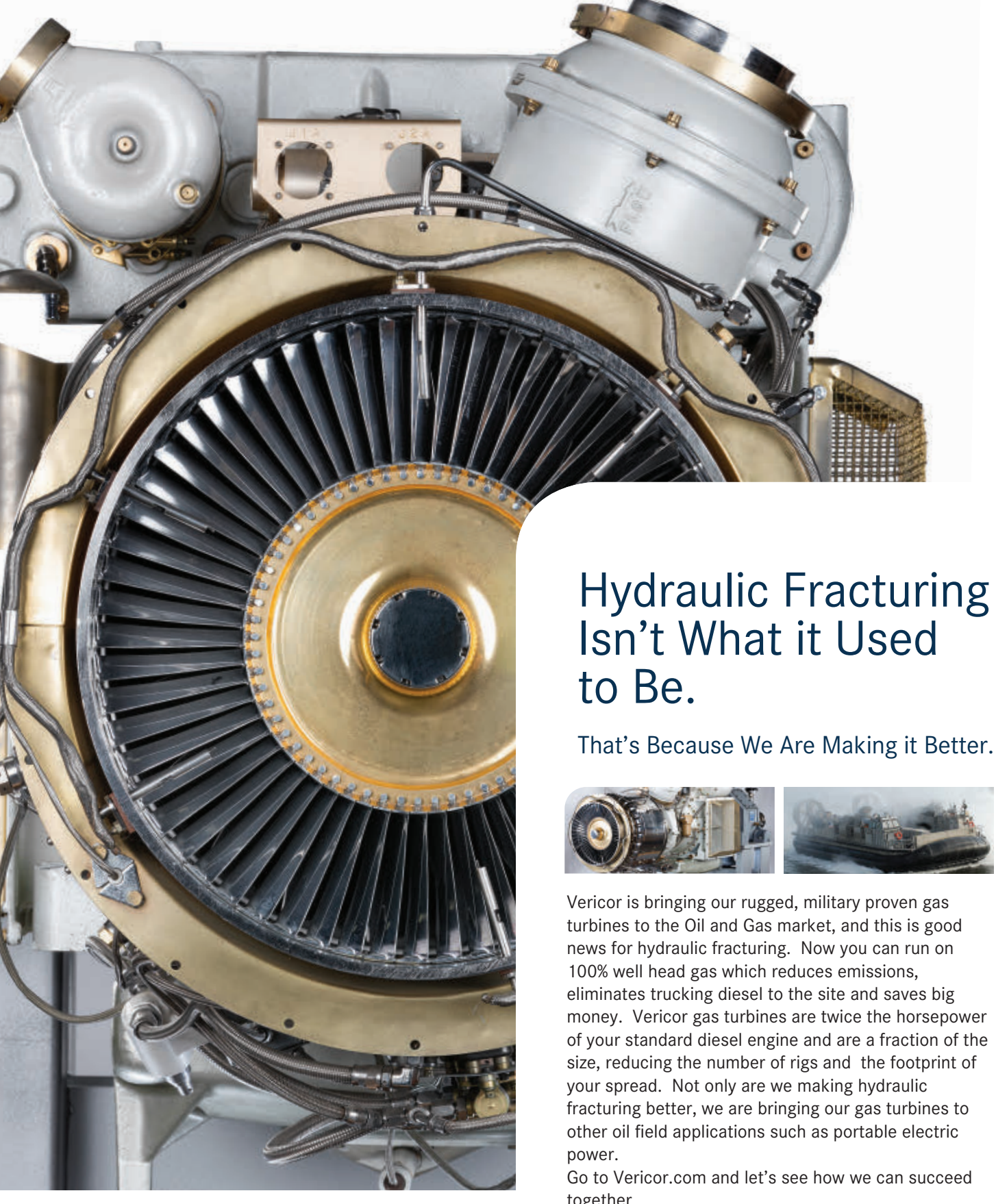
Cutt appointed Cobalt International CEO

Timothy J. Cutt has been named chief executive officer and Class 1 member of the board of directors of Cobalt International Energy Inc., Houston, effective July 2. Until last March, he was president, petroleum, of BHP Billiton.

Cutt, who has worked in the oil and gas industry more than 30 years, succeeds Joseph H. Bryant, who resigned as CEO and chairman and member of the board.

Van P. Whitfield, executive vice-president and chief operating officer, was appointed interim CEO effective June 1 and a Class 2 member of the board.

Also effective June 1, William P. Utt, lead independent director, was appointed interim chairman. OGJ



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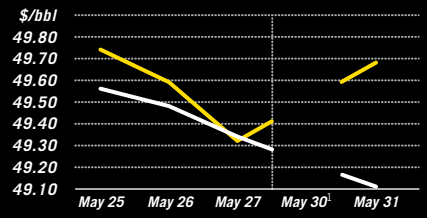
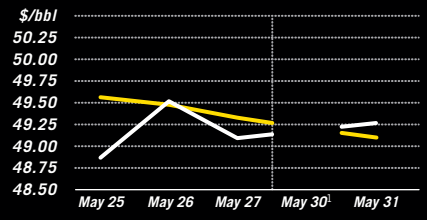
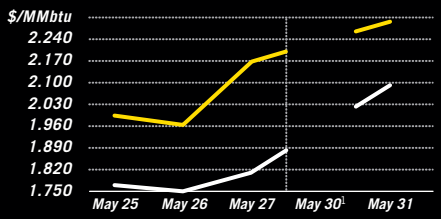


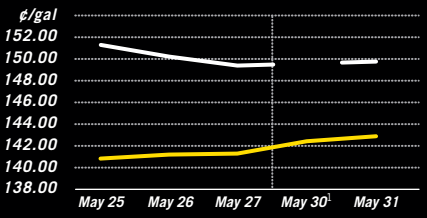
WTI CUSHING / BRENT SPOT



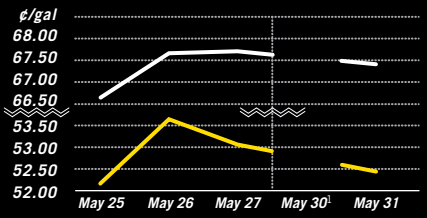
NYMEX NATURAL GAS / SPOT GAS - HENRY HUB



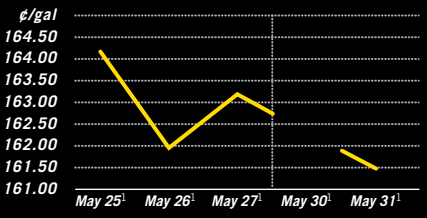
ICE GAS OIL / NYMEX HEATING OIL



PROPANE - MT. BELVIEU / BUTANE - MT. BELVIEU



NYMEX GASOLINE (RBOB)[2] / NY SPOT GASOLINE[3]



[1]Not available [2]Reformulated gasoline blendstock for oxygen blending [3]Nonoxygenated regular unleaded

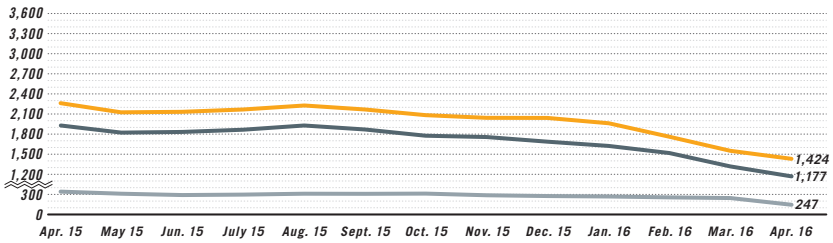
US INDUSTRY SCOREBOARD — 6/6

Latest week 5/20	4 wk. average	4 wk. avg. year ago[1]	Change, %	YTD average[1]	YTD avg. year ago[1]	Change, %
Product supplied, 1,000 b/d						
Motor gasoline	9,608	9,245	3.9	9,277	8,913	4.1
Distillate	4,094	4,130	(0.9)	3,739	4,057	(7.8)
Jet fuel	1,614	1,530	5.5	1,563	1,527	2.4
Residual	335	168	99.4	297	207	43.5
Other products	4,701	4,693	0.2	4,959	4,807	3.2
TOTAL PRODUCT SUPPLIED	20,352	19,766	3.0	19,835	19,511	1.7
Supply, 1,000 b/d						
Crude production	8,796	9,393	(6.4)	9,033	9,327	(3.2)
NGL production[2]	3,323	3,100	7.2	3,398	3,080	10.3
Crude imports	7,577	6,829	11.0	7,804	7,271	7.3
Product imports	2,245	2,082	7.8	2,082	2,072	0.5
Other supply[2 3]	2,161	2,173	(0.6)	2,020	2,372	(14.8)
TOTAL SUPPLY	24,102	23,577	2.2	24,337	24,122	0.9
Net product imports	(1,363)	(1,394)	—	(1,845)	(1,581)	—
Refining, 1,000 b/d						
Crude runs to stills	16,204	16,638	(2.6)	16,023	15,866	1.0
Input to crude stills	16,437	16,587	(0.9)	16,221	16,093	0.8
% utilization	89.8	92.4	—	89.2	89.8	—

Latest week 5/20	Latest week	Previous week[1]	Change	Same week year ago[1]	Change	Change, %
Stocks, 1,000 bbl						
Crude oil	537,068	541,294	(4,226)	479,363	57,705	12.0
Motor gasoline	240,111	238,068	2,043	220,627	19,484	8.8
Distillate	150,878	152,162	(1,284)	128,839	22,039	17.1
Jet fuel–kerosine	43,138	43,151	(13)	38,453	4,685	12.2
Residual	41,773	41,914	(141)	40,324	1,449	3.6
Stock cover (days)[4]			Change, %		Change, %	
Crude	33.1	33.6	(1.5)	29.5	12.2	
Motor gasoline	25.0	24.9	0.4	23.9	4.6	
Distillate	36.9	37.1	(0.5)	31.2	18.3	
Propane	70.9	76.6	(7.4)	76.0	(6.7)	
Futures prices[5] **5/27**			Change		Change	Change,%
Light sweet crude ($/bbl)	49.01	48.03	0.98	59.22	(10.21)	(17.2)
Natural gas, $/MMbtu	2.03	2.04	—	2.94	(0.91)	(30.9)

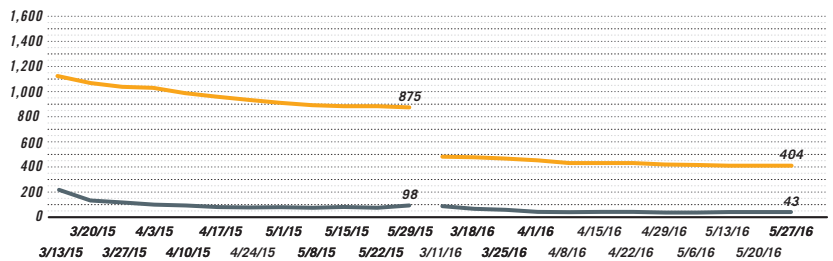
[1]Based on revised figures. [2]OGJ estimates. [3]Includes other liquids, refinery processing gain, and unaccounted for crude oil. [4]Stocks divided by average daily product supplied for the prior 4 weeks. [5]Weekly average of daily closing futures prices.
Source: Energy Information Administration, Wall 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

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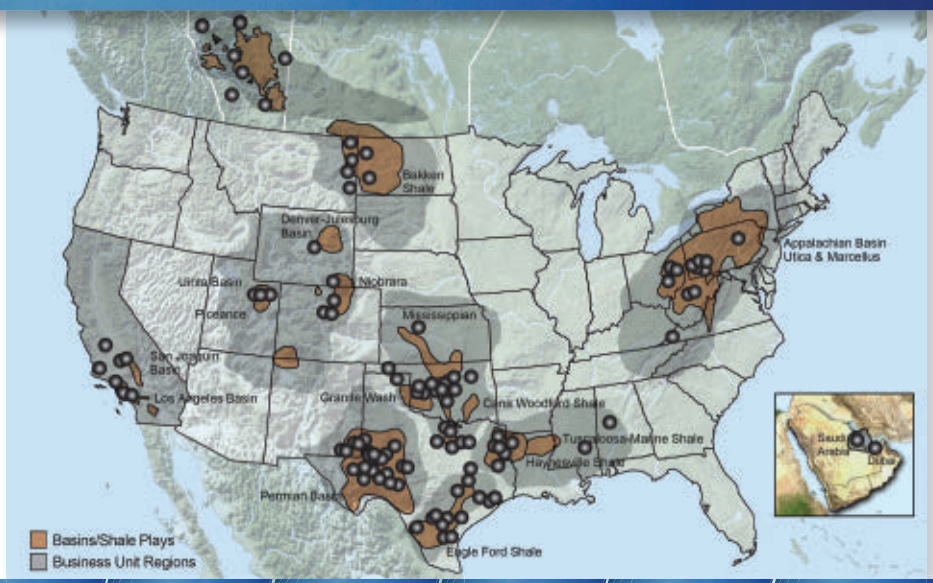

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MID-CON	✓	✓	✓	✓	✓	✓
ROCKIES	✓	✓	✓	✓	✓	✓
NORTH EAST	✓	✓	✓	✓	✓	✓
CALIFORNIA		✓	✓	✓	✓	✓

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EXPLORATION & DEVELOPMENT QUICK TAKES

NPD studies cores from northeastern Barents Sea

The Norwegian Petroleum Directorate had seven shallow wells drilled in the northeastern Barents Sea in fall 2015, resulting in 1,000 m of stratigraphic drill cores to help assess the resource base.

The area is not open for petroleum activity. NPD did not disclose the well depths.

Meter by meter, the cores are being examined and registered in the NPD "core store" in Stavanger. NPD said the cores provide "a quick overview of rock types and sedimentary structures."

Containing source and reservoir rocks, the cores measure 5-7 cm in diameter and are split lengthwise. They are being studied with a magnifying glass, tape measure, and hydrochloric acid.

"Once these studies have been completed, we will understand much more about the geology in these sea areas," said Andreas Bjornestad, a geologist who participated in the drilling expedition with the vessel Bucentaur (OGJ Online, Feb. 28, 2013).

The cores were initially brought to the NPD core store in Trondheim, where three consultants readied them for descriptions. In April, they were moved to Stavanger, which holds samples and drill cuttings from nearly all exploration and production wells drilled on the Norwegian shelf. The vast majority of those drill cores are from reservoir rocks, NPD said.

NPD greenlights North Sea wildcat, Brasse prospect

The Norwegian Petroleum Directorate has granted Faroe Petroleum Norge AS a permit for well 31/7-1 on its jointly owned Brasse prospect in PL740. The area in this licence is part of Blocks 31/7 and 30/9. PL740 was awarded in APA 2013. This is the first well to be drilled in the license.

According to Faroe's web site, the prospect holds stacked reservoir potential in Upper and Middle Jurassic. Well 31/07-01 will be drilled from the Transocean Arctic drilling facility and is expected to spud sometime in mid-2016. Faroe holds equal interest in PL740 with Core Energy AS.

Drilling approved for Indonesia's South Block A

Indonesia has approved the Amanah Timur No. 1 (AT1) appraisal well, and ACL International Ltd.'s subsidiary Renco Elang Energy Ltd. said the well will spud before Nov. 30. Renco, the operator of South Block A, is drilling AT1 to test the Paya Bili prospect at TD of 700 m and to evaluate reservoir productivity in a pre-1940 oil field as well as deeper untested sandstones.

South Block A is onshore and offshore Aceh Province, North Sumatra, Indonesia (OGJ Online, May 18, 2009). The prospect lies within the North Sumatra basin and is one of the most productive hydrocarbon provinces in Indonesia with more than 80 known oil and gas fields. ACL acquired 38.25% interest in South Block A in July 2015.

South Block A is split into two portions. The West block covers 1,257 sq km onshore the North Sumatra. The East block covers 637 sq km, extending into the coastal area and offshore. East block also includes four exploration wells and 180 km of 2D seismic.

The operator estimates combined P50 unrisked resources at 442 bcf of gas and 47 million bbl of oil and condensate. The probability of success with identified leads range from 11% to 48%, the company said.

The JV recently completed 183 km of 2D seismic survey, which targeted the Simpang, Djerneh, Amanah, Sungai Lyu, and Paya Bili prospects. Lion Energy Ltd.'s operational update cites the Simpang Deep as the largest of the identified leads, which has more than 25 sq km potential areal closure with similar objectives as the Matang discovery (OGJ Online, Apr. 23, 2016). The JV may select this target for a planned late-2017 drilling campaign.

JV partner Lion Energy holds 35% interest in South Block A through its subsidiary KRX Energy (SBA) Pte. Ltd. According to the company's web site, Renco holds 51% overall as operator of the block, and PT Prosys Oil & Gas International also holds a participating interest.

Black Sea seismic program under way off Romania

Carlyle Group's Black Sea Oil & Gas SRL has awarded GC Rieber Shipping a 45-day contract for seismic work offshore Romania in the Black Sea. Wholly owned subsidiary Dolphin Geophysical Ltd. will deliver fast-track 3D seismic with its 16-streamer Polar Marquis.

Black Sea Oil & Gas has interest in three blocks, XIII Pelican, XV Midia Shallow, and EX-25 Luceafarul, which cover 5,000 sq km within the underexplored Romanian continental shelf. Black Sea Oil & Gas operates the blocks on behalf of its partners Gas Plus International BV (Midia and Pelican) and Petro Ventures Europe BV (Midia, Pelican, and Luceafarul).

On May 11 OMV AG said its subsidiary OMV Petrom SA completed a second exploration drilling campaign in January on its Neptun Deep block offshore Romania. In all, seven wells were finalized with most encountering gas (OGJ Online, May 12, 2016). The company said further interpretation was needed to determine commercial viability, but in 2013 OMV assessed that Neptun might produce 6.5 billion cu m/year. First production is expected before 2020. ExxonMobil Corp. is an equal 50% partner. OGJ

DRILLING & PRODUCTION QUICK TAKES

EIA: US oil output in March fell 5.4% year-over-year

US crude oil production in March averaged 9.127 million b/d, down from 9.133 million b/d in February and 9.648 million b/d in March 2015, according to the most recent data from the US Energy Information Administration.

The overall US crude output decline was led by a more than

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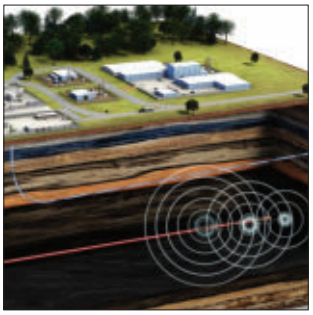

ULTRA-DEEPWATER | UNCONVENTIONAL RESOURCES | SMALL PRODUCER

10% drop year-over-year in Texas. Production in the state during March totaled 3.276 million b/d, decreasing from 3.316 million b/d in February and 3.644 million b/d in March 2015.

North Dakota output during the month was 1.109 million b/d, down from 1.116 million b/d in February and 1.189 in March 2015.

Onshore production declines were partially offset by a 16% year-over-year jump in production from federal waters of the Gulf of Mexico, where March output averaged 1.641 million b/d, rising from 1.577 million b/d in February and 1.414 million b/d in March 2015.

US natural gas production in March was 91.06 bcf, down from 92.011 bcf in February but still up from 90.768 bcf in March 2015. Texas's gas output was 22.605 bcf, falling from 22.931 bcf in February and 24.087 bcf in March 2015.

Pennsylvania's gas output totaled 14.67 bcf, down from 14.945 bcf in February but still up 11.2% year-over-year from 13.191 bcf. Gas production from the Gulf of Mexico totaled 3.562 bcf, up from 3.496 bcf in February and 3.203 bcf in March 2015.

EIA: Permian oil-output drop to increase in June

Crude oil production in June from the seven major US shale regions is expected to fall 113,000 b/d month-over-month to 4.85 million b/d, according to the US Energy Information Administration's latest Drilling Productivity Report (DPR).

The DPR focuses on the Bakken, Eagle Ford, Haynesville, Marcellus, Niobrara, Permian, and Utica, which altogether accounted for 95% of US crude production increases and all US natural gas production increases during 2011-13.

For the third consecutive month, the Permian is forecast to record an oil-output decline. The projected 10,000-b/d loss in June would bring its total output to 2.02 million b/d. The West Texas basin was the last major oil-producing region for which the EIA projected a monthly loss since overall US shale output began falling in spring 2015.

In South Texas, the Eagle Ford is again expected to represent most of the overall US loss in June, shedding 58,000 b/d to 1.21 million b/d. The Bakken is projected to drop 28,000 b/d to 1.02 million b/d, and the Niobrara is projected to drop 15,000 b/d to 391,000 b/d.

New-well oil production/rig in June across the seven regions is expected to rise by a rig-weighted average of 13 b/d to 575 b/d, reflecting a 23-b/d jump in the Eagle Ford to 994, 23-b/d gain in the Niobrara to 915, 17-b/d increase in the Bakken to 832 b/d, and 13-b/d rise in the Permian to 493 b/d.

Gas production from the regions is forecast to fall 464 MMcfd to 45.97 bcfd. The Eagle Ford is expected to lose 195 MMcfd to 6.3 bcfd, followed by a 74-MMcfd drop in the Niobrara to 4.11 bcfd, 64-MMcfd decrease in the Haynesville to 5.98 bcfd, and 53-MMcfd losses in each of the Marcellus and Permian to 17.29 bcfd and 6.97 bcfd, respectively.

EIA projects gas output from the Utica to increase 4 MMcfd to 3.66 bcfd. OGJ

PROCESSING QUICK TAKES

Rosneft, Pertamina ink deal for integrated complex

Russia's OJSC Rosneft and PT Pertamina (Persoro) of Indonesia have signed a framework agreement to cooperate on development of a grassroots refining and petrochemical complex to be built at Tuban, in East Java, Indonesia.

As part of the agreement, Rosneft and Pertamina will perform a bankable feasibility study to finance the project as well as establish a joint venture for its implementation, Rosneft said.

The companies also have agreed to execute studies to investigate the following: prospects for joint projects in the area of crude and oil products supplies, logistics, and infrastructure; potential for Pertamina to enter in Rosneft's upstream projects in Russia as an equity holder; and partnership in international joint projects for refining.

Rosneft said the companies will take final investment decision on the proposed complex once they have completed the feasibility study, basic engineering design (BED), and front-end engineering design (FEED) for the project.

The agreement follows Pertamina's previously announced plans to build refineries and upgrade existing plants as part of its strategy to reduce fuel imports into Indonesia by boosting domestic production (OGJ Online, Dec. 15, 2014).

Rosneft, which has led competition for a share in the long-stalled Tuban complex, views the deal as a launching pad for expanding its footprint as a reliable partner in oil and gas production as well as refining throughout the Asia-Pacific region.

A timeframe for when the firms would complete the feasibility study, BED, and FEED on the project was not disclosed.

Lukoil commissions unit at Volgograd refinery

PJSC Lukoil subsidiary OOO Lukoil Volgogradneftepererabotka has commissioned a vacuum gas oil (VGO) deep-conversion hydrocracking complex at its Volgograd refinery in southern Russia as part of a program to boost overall capacities of the company's refining assets (OGJ Online, Feb. 19, 2013).

Entered into commercial operation on May 31, the deep-processing complex includes a 3.5 million-tonne/year VGO hydrocracker, units for hydrogen production and sulfur recovery, as well as auxiliary installations, Lukoil said.

Completed in 3 years at a cost of $2.2 billion, the complex will increase the refinery's annual output of the following products for primary distribution to markets in southern parts of Russia: Euro 5 diesel fuels by 1.8 million tpy, motor gasoline components by 600,000 tpy, and LPGs by 100,000 tpy.

Startup of the Volgograd deep-processing complex establishes Lukoil as the first Russian operator to fulfill its commitments under a July 2011 quadripartite agreement on modernization of Russia's oil processing industry between oil companies; the Federal Antimonopoly Service of the Russian Federation; the Federal Service for Environmental, Technological, and Nuclear Supervision (Rostechnadzor); and the Federal Agency for Technical Regulating and Metrology (Rosstandart) to reequip and

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upgrade oil processing capacities at the country's refineries.

Addition of the complex at Volgograd follows Lukoil's June 2015 commissioning of the 6 million-tpy AVT-1 crude distillation unit at the refinery (OGJ Online, June 25, 2015; Feb. 20, 2015), which has lifted crude oil processing capacity at the site to a current 15.7 million tpy from its previous 11 million-tpy capacity, Lukoil said in its latest annual report.

CPC lets contract for Cambodian grassroots refinery

Petrochemical Co. Ltd. (CPC) has let a contract to China National Petroleum Corp. (CNPC) unit Northeast Refining & Chemical Engineering Co. to build the first phase of a proposed 5 million-tonne/year refinery in Cambodia's southwestern province of Preah Sihanouk, along the Gulf of Thailand.

As part of the $620-million Phase 1 contract, CNPC Northeast Refining & Chemical Engineering will provide engineering, procurement, and construction on the project, according to a series of releases from Cambodia's government.

Construction on Phase 1 of the refinery, which will have a capacity of 2 million tpy, is scheduled to begin this October and be completed by yearend 2018.

In the years following commissioning of Phase 1, CPC plans to invest in additional expansions of the refinery that will increase its overall crude processing capacity to 5 million tpy, according to the government of Cambodia.

CPC's total capital investment in the grassroots refinery will be about $3 billion, the company said.

The new refinery—which will be Cambodia's first since a 10,000-b/d plant built in 1968 was irreparably damaged in the early 1970's during the country's civil war—will produce finished products for domestic consumption as well as export, Cambodia's Ministry of Mines & Energy said in a post to its official Facebook account.

CPC previously let a licensing and engineering services contract to KBR and Tinajin Petrochemical Engineering Design Co. Ltd. for a 1.2 million-tpy hydrocracker for a proposed 5-million-tpy refinery originally planned for startup in 2015 in Cambodia's Kampong Som Petrochemical Industrial Zone (OGJ Online, Jan. 18, 2013).

It remains unclear whether contracts let for earlier iterations of the long-planned refinery remain in effect under CPC's revised program for the plant. OGJ

TRANSPORTATION QUICK TAKES

Gladstone LNG's second train starts up

The Santos Ltd.-led $18.5-billion Gladstone LNG (GLNG) project on Curtis Island near Gladstone in central east coast Queensland has brought on line its Train 2, just 8 months after Train 1. The Santos group has produced in excess of 2 million tonnes of LNG since Train 1 came on stream in October 2015 and shipped 32 cargoes in that time.

The JV comprises Santos 30%, Petronas 27.5%, Total SA 27.5%, and Korea Gas Corp. 15%.

The three coal seam gas-LNG projects on Curtis Island now have five out of the six planned trains in operation. These include GLNG (2 trains), BG's Queensland Curtis LNG (2 trains) and Origin Energy's Australia Pacific LNG (1 train).

All gas supplies are being sourced from the Surat-Bowen basins of inland southeast Queensland.

Chevron gets environmental nod for Gorgon Train 4

The Australian government has granted environmental approval to Chevron Australia Pty. Ltd. for Train 4 at the firm's $54-billion Gorgon-Jansz LNG plant on Barrow Island off Western Australia. Valid until yearend 2069, the expansion approval has numerous stringent environmental management, monitoring, and reporting conditions attached.

At this stage, however, Chevron has little inclination to move into a Train 4 mode. The company and its joint venture partners recently began production with Train 1, while Trains 2 and 3 are still under construction. Train 1 was shut down for repairs for 2 months soon after coming on stream, but is now back online.

The JV's priority is to complete the foundation project of three trains and has yet to make a decision to proceed with planning of a fourth. Train 2 is due to come online later this year with Train 3 just 6 months after that.

Slumping oil prices and oversupply in the global LNG market has dampened the zest for further expansion in the short term, although there appears to be plenty of gas in undeveloped fields in the Greater Gorgon region to support a fourth train.

Nevertheless the government approval and its timeframe does provide environmental certainty should a decision to proceed with Train 4 be made in the future.

HMEP to build US-Mexico refined products line

Howard Midstream Energy Partners LLC (HMEP) unit Dos Aguilas Pipeline LLC will build the 287-mile, 12-in. OD Dos Aguilas products pipeline following a successful open season. Dos Aguilas is an open access system of refined products terminals and pipelines from Corpus Christi, Tex., to northern Mexico. HMEP expects the project to service first-half 2018.

Dos Aguilas will ship gasoline, ultra-low sulfur diesel, and jet fuel from the Corpus Christi refinery to Laredo, Tex., and on to northern Mexico through deliveries to Nuevo Laredo, Tamaulipas, and Monterrey, Nuevo Leon. The project is broken down for regulatory purposes into four pipelines, with different names: Border Express Pipeline, Corpus Christi to Laredo (141 miles); Borrego Pipeline, Laredo to the US-Mexico border (10 miles); Poliducto Frontera Pipeline, US-Mexico border to Nuevo Laredo (12 miles); and Poliducto del Norte Pipeline, Nuevo Laredo to Monterrey (124 miles).

Howard will build terminals, with a combined 1.2 million bbl of storage, at the pipeline's start in Robstown, Tex., Laredo, Nuevo Laredo, and at the pipeline's end in Santa Catarina, Mexico, near Monterrey. OGJ

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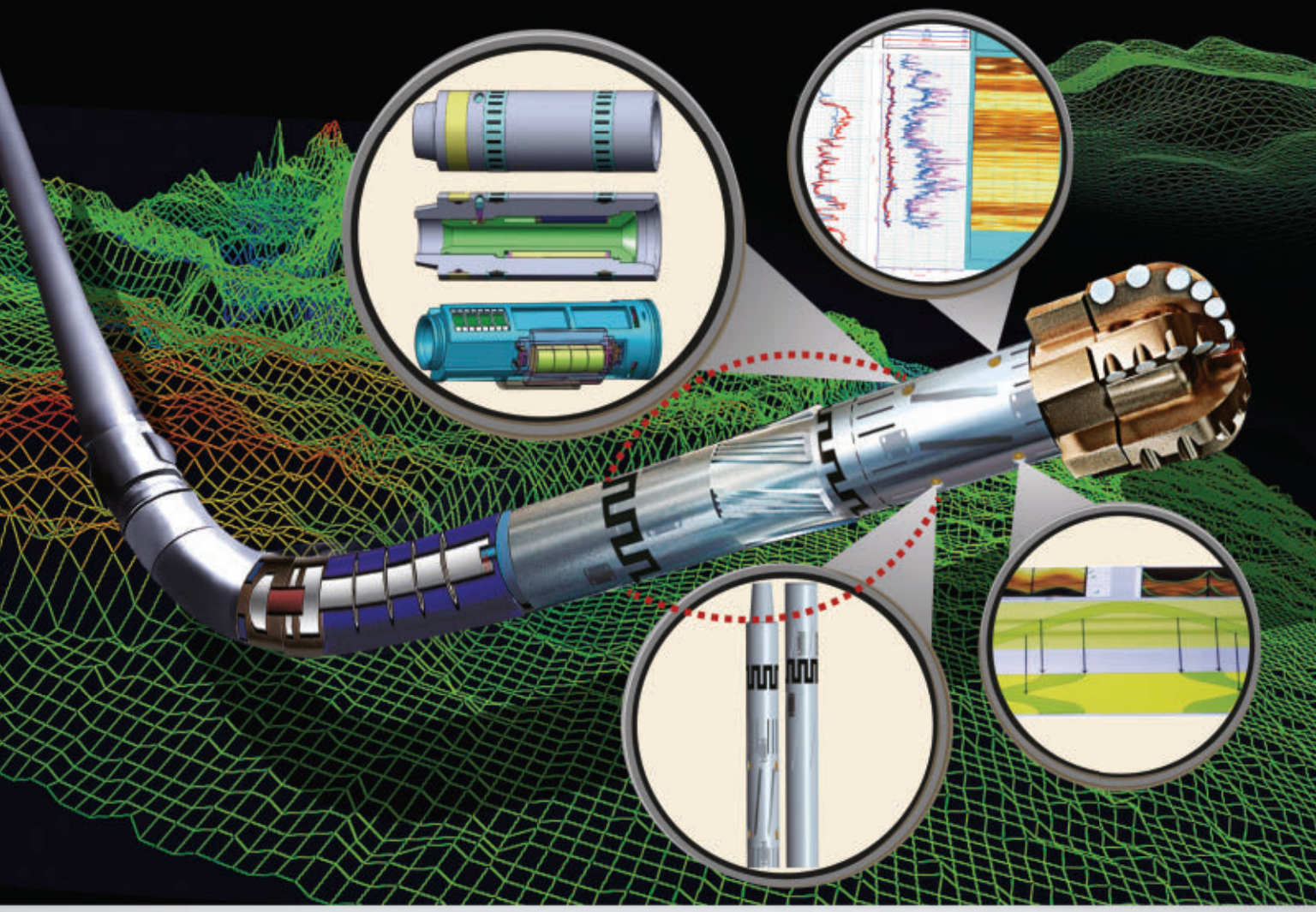

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■ *Denotes new listing or a change in previously published information.*

JUNE 2016

SPE Argentina Exploration & Production of Unconventional Resources Symposium, Buenos Aires, web site: www.spe.org/events/laur/2016/ **1-3.**

23rd International Caspian Oil & Gas Conference, Baku, web site: www.oilgasconference.az/2016/?p=index **2-3.**

Society of Petroleum Evaluation Engineers (SPEE) 53rd Annual Meeting, Lake Tahoe, NV, web site: https://secure.spee.org/ **4-9.**

Canadian Energy Research Institute (CERI) 2016 Petrochemical Conference, Kananaskis, Alta., web site: ceri.ca/index.php?option=com_content&view=article&id=57&Itemid=60 **5-7.**

Australian Petroleum Production & Exploration Association (APPEA) Conference & Exhibition, Brisbane, web site: www.appeaconference.com.au/ **5-8.**

SPE Canada Heavy Oil Technical Conference, Calgary, web site: www.spe.org/events/choc/2016/ **7-9.**

Caspian Oil & Gas Exhibition, Baku, web site: www.oilgas-events.com/Caspian-OG-Exhibition/ **7-10.**

Internet of Things (IOT) in Oil & Gas Europe, Aberdeen, web site: energyconferencenetwork.com/iot-oil-gas-europe-2016/ **8-9.**

SPE Trinidad & Tobago Section Energy Resources Conference, Port of Spain, web site: spettconf.org/ **13-15.**

Nigeria Oil & Gas Conference & Exhibition, Abuja, Nigeria, web site: www.cwcnog.com/ **13-16.**

SPE London Annual Conference: Adapting to a Challenging Oil Price Environment, London, web site: www.spe.org/events/lond/2016/ **14.**

Oil & Gas Polymer Engineering Texas 2016, Houston, web site: www.amiplastics-na.com/events/Event.aspx?code=C734&sec=5725 **14-15.**

LNG Fuels Summit, Amsterdam, website: www.lngfuelssummit.com/**14-15.**

CWC's LNG Fuels Summit, Amsterdam, web site: www.lngfuelssummit.com/ **14-16.**

IADC World Drilling 2016 Conference & Exhibition, Lisbon, www.iadc.org/event/world-drilling-2016/ **15-16.**

IADC World Drilling Conference & Exhibition, Lisbon, web site: www.iadc.org/event/world-drilling-2016/ **15-16.**

AAPG Annual Convention & Exhibition 2016, Calgary, web site: ace.aapg.org/2016 **19-22.**

AAPG 2016 Annual Convention & Exhibition, Calgary, web site: www.aapg.org/events/conferences/ace/ **19-22.**

North American Custody Transfer Measurement Conference, San Antonio, web site: www.ceesi.com **21-23.**

The 4th Annual Cyber Security for Oil & Gas Summit, Houston, web site: www.oilandgas-cybersecurity.com/ **27-29.**

Independent Petroleum Association of America (IPAA) 86th Midyear Meeting, Colorado Springs, Colo., web site: www.ipaa.org/meeting-events/event-details/?mid=266 **27-29.**

2016 Exploration & Production Standards Conference on Oilfield Equipment & Materials, Washington, DC, web site: www.api.org/events-and-training/calendar-of-events/2016/e-p **June 27-July 1.**

Papua New Guinea Oil & Gas Summit, Port Moresby, web site: pngoilgas.com/ **28-29.**

JULY 2016

World Congress on Petroleum & Refinery, Brisbane, web site: petroleum.omicsgroup.com/ **21-23.**

AUGUST 2016

SPE/AAPG/SEG Unconventional Resources Technology Conference (URTeC), San Antonio, web site: www.urtec.org/ **1-3.**

Society of Petroleum Engineers (SPE) Nigeria Annual International Conference & Exhibition, Lagos, web site: connect.spe.org/spenc/naice/naice2016/ **2-4.**

NAPE Expo, Houston, web site: napeexpo.com/shows/about-the-show/houston/ **10-11.**

EnerCom's The Oil & Gas Conference-2016, Denver, web site: www.theoilandgasconference.com/ **14-18.**

IADC/SPE Asia Pacific Drilling Technology Conference & Exhibition, Singapore, web site: www.spe.org/events/apdt/2016/ **22-24.**

GeoBaikal 2016: Expand Horizons, Irkutsk, Russia, web site: www.eage.org/event/index.php?eventid=1433&Opendivs=s3 **22-26.**

SPE Asia Pacific Hydraulic Fracturing Conference, Beijing, web site: www.spe.org/events/aphf/2016/pages/general/call_for_papers.php **24-26.**

15th European Conference on the Mathematics of Oil Recovery (ECMOR XV), Amsterdam, web site: www.eage.org/event/index.php?eventid=1416&Opendivs=s3 **Aug. 29-Sept. 1.**

Offshore Northern Seas, Stavanger, web site: www.tofairs.com/expo.php?fair=103366 **Aug. 29-Sept. 1.**

2nd International Congress & Expo on Biofuels & Bioenergy, Sao Paulo, web site: biofuels-bioenergy.conferenceseries.com/ **29-31.**

SEPTEMBER 2016

Second Applied Shallow Marine Geophysics Conference, Barcelona, web site: www. Eage.org/event/index.php?eventid=1421&Opendivs=s3 **4-8.**

EAGE First Conference on Geophysics for Mineral Exploration and Mining, Barcelona, web site: www.eage.org/event/?eventid=1420 **4-8.**

European Association of Geoscientists & Engineers (EAGE) First Conference on Geophysics for Mineral Exploration & Mining, Barcelona, web site: www.eage.org/event/index.php?eventid=1420&Opendivs=s3 **4-8.**

22nd European Meeting of Environmental and Engineering Geophysics, Barcelona, web site: www.eage.org/event/index.php?eventid=1419&Opendivs=s3 **4-8.**

SPE Offshore Europe, Aberdeen, web site: www.offshore-europe.co.uk/ **5-8.**

SPE Intelligent Energy Conference, Aberdeen, web site: www.intelligentenergyevent.com/ **6-8.**

NACE Egypt Corrosion Conference, Cairo, web site: egyptcorrosion.nace.org/ **6-8.**

AAPG SEG International Conference & Exhibition 2016, Cancun, web site: www.aapg.org/publications/blogs/events/article/articleid/23667/increase-your-exposure-exhibition-and-sponsorship-opportunities-available/ **6-9.**

AAPG SEG 2016 International Conference & Exhibition, Cancun, web site: www.aapg.org/events/conferences/ice/announcement/articleid/20311/aapg-seg-2016-international-conference-exhibition-cancun **6-9.**

23rd Annual India Oil & Gas Review Summit & International Exhibition, Mumbai, web site: www.oilgas-events.com/india-oil-gas **9-10.**

International Conference on Chemical Engineering, Phoenix, web site: chemicalengineering.conferenceseries.com/ **12-14**.

Geomodel 2016, Gelendzhik, Russia, web site: www.eage.org/event/index.php?eventid=1448&Opendivs=s3 **12-15.**

ESOPE International Exhibition & Symposium for the Pressure Equipment Industry, Paris, web site: www.esope-paris.com/ **13-15.**

SPE Deepwater Drilling & Completions Conference, Galveston, Tex., web site: www.spe.org/events/ddc/2016/ **14-15.**

2nd Annual IoT in Oil & Gas, Houston, web site: energyconferencenetwork.com/iot-in-oil-and-gas-2016/**14-15.**

Rio Oil & Gas Expo & Conference, Rio de Janeiro, web site: www.whereinfair.com/rio-oil-gas-expo/rio-de-janeiro/2016-Sep/ **14-16.**

Turbomachinery & Pump Users Symposium, Houston, web site: tps.tamu.edu/event-info **15-17.**

Iran International Petroleum Congress (IIPC), Tehran, web site: www.iranpetroleumcongress.com/ **19-21.**

The CWC World LNG & Gas Series: Asia Pacific Summit, Singapore, web site: asiapacific.cwclng.com/ **20-23**.

SPE Liquids-Rich Basins Conference—North America, Midland, Tex., web site: www.spe.org/events/lrbc/2016/ **21-22.**

Eastern Section, American Association of Petroleum Geologists 2016 Annual Meeting, Lexington, Ky., web site: www.esaapgmtg.org/ **25-27.**

Corrosion Technology Week 2016, Houston, web site: ctw.nace.org/ **25-29**.

SPE Annual Technical Conference & Exhibition (ATCE), Dubai, web site: www.spe.org/atce/2016/ **26-28.**

SPE Annual Technical Conference & Exhibition, Dubai, web site: www.spe.org/events/calendar/ **26-28.**

Global Oil & Gas South East Europe & Mediterranean Conference, Athens, web site: www.oilgas-events.com/Global-Oil-Gas-Black-Sea-Mediterranean-Conference/ **28-29.**

International Conference on Geophysics, Vancouver, web site: geophysics.conferenceseries.com/ **29-30.**

OCTOBER 2016

Kazakhstan International Oil & Gas Conference (KIOGE) 2016, Almaty, Kazakhstan, web site: kioge.kz/en/conference/about-conference **5-6.**

USEA 9th Annual Energy Supply Forum, Washington, DC, web site: https://www.usea.org/event/usea-9th-annual-energy-supply-forum **6.**

International Conference on Geosciences, Orlando, web site: geosciences.conferenceseries.com/ **6-7.**

Cyber Security for Critical Assets LATAM, Rio de Janeiro, web site: www.criticalcybersecurity.com/latam/ **6-7.**

23rd World Energy Conference, Istanbul, web site: www.wec2016istanbul.org.tr/ **9-13.**

The 2016 API Tank, Valves, & Piping Conference & Expo, Las Vegas, web site: www.api.org/events-and-training/calendar-of-events/2016/tvp **10-13.**

SEG International Exhibition and 86th Annual Meeting, Dallas, web site: www.seg.org/web/annual-meeting-2016/ **16-21.**

The 8th Saudi Arabia International Oil & Gas Exhibition (SAOGE), Dammam, web site: www.saoge.org/ **17-19.**

SPE Well Construction Fluids 2025 Forum: Meeting the Challenges, Dubai, web site: www.spe.org/events/16fmel/ **17-19.**

2016 Fall Committee on Petroleum Measurement Standards Meeting, Los Angeles, web site: www.api.org/Events-and-

Training/Calendar-of-Events/2016/fallcopm **17-21.**

The 37th Oil & Money Conference, London, web site: www.oilandmoney.com/ **18-19.**

Society of Petroleum Engineers (SPE) African Health, Safety, Security, Environment & Social Responsibility Conference & Exhibition, Accra, Ghana, web site: www.spe.org/events/hsea/2016/ **18-20.**

SPE Latin America & Caribbean Heavy Oil & Extra Heavy Oil Conference, Lima, web site: www.spe.org/events/laho/2016/ **19-20.**

Arctic Technology Conference (ATC), St. John's, Newfoundland & Labrador, web site: www.arctictechnologyconference.org/ **24-26.**

SPE Russian Petroleum Technology Conference & Exhibition, Moscow, web site: www.spe.org/events/rpc/2016/ **24-26.**

SPE North America Artificial Lift Conference & Exhibition, The Woodlands, Tex., web site: www.spe.org/events/alce/2016/ **25-27.**

SPE Asia Pacific Oil & Gas Conference & Exhibition (APOGCE), Perth, web site: www.spe.org/events/apogce/2016/ **25-27.**

The 10th Element Oilfield Engineering with Polymers Conference, London, web site: oilfieldpolymers.nace.org/ **25-27.**

Bottom of the Barrel Technology Conference (BBTC) Middle East & Africa 2016, Manama, web site: www.bbtc-mena.biz **26-27.**

Gulf Safety Forum (GSF) 2016, Doha, web site: www.gulfsafetyforum.com/ **30-31.**

23rd Africa Oil Week Africa Upstream Conference 2016, Cape Town, web site: www.oilgas-events.com/Find-an-Event/Africa-Oil-Week/ **Oct 31-Nov 04.**

NOVEMBER 2016

2nd International Conference & Expo on Oil & Gas, Istanbul, web site: oil-gas.omics-group.com/ **2-3.**

The Abu Dhabi International Petroleum Exhibition & Conference, (ADIPEC), Abu Dhabi, web site: www.adipec.com/ **7-10.**

RefComm Mumbai 2016, Mumbai, web site: refiningcommunity.com/refcomm-mumbai-2016/ **7-11.**

International Petroleum Technology Conference (IPTC), Bangkok, web site: www.iptcnet.org/pages/about/future-dates.php **14-16.**

4th East Africa Oil & Gas Summit & Exhibition, Nairobi, web site: eaogs.com/**15-17.**

21st Annual Oil & Gas of Turkmenistan (OGT) Conference 2016, Ashgabat, web site: ogt.theenergyexchange.co.uk/ **16-17.**

5th International Conference on Petroleum Geology & Petroleum Industry, Dubai, web site: petroleumgeology.conferenceseries.com/ **24-25.**

Oil & Gas Safety & Health Conference 2016 OSHA Exploration & Production, Houston, web site: www.oshasafetyconference.org/Events/ugm/Osha2016/default.aspx **29-30.**

Society of Petroleum Engineers (SPE) Middle East Artificial Lift Conference & Exhibition, Manama, Bahrain, web site: www.spe.org/events/meal/2016/ **Nov. 30-Dec. 1.**

DECEMBER 2016

Third EAGE Integrated Reservoir Modelling Conference, Kuala Lumpur, web site: www.eage.org/event/index.php?eventid=1477&Opendivs=s3 **5-7.**

OpEx MENA 2016—Operational Excellence in Oil, Gas & Petrochemicals, Abu Dhabi, web site: www.opex.biz **5-7.**

Oil & Gas Supply Chain Procurement, Houston, web site: energyconference.network.com/oil-gas-supply-chain-procurement-2016/ **6-7.**

SPE Heavy Oil Conference & Exhibition, Kuwait City, web site: www.spe.org/events/hoce/2016/ **6-8.**

Green Forum: Oil, Gas & Petrochemicals, Abu Dhabi, web site: www.greenforum.ae **8.**

JANUARY 2017

Global Oil & Gas Middle East & North Africa Conference, Cairo, web site: www.oilgas-events.com/Find-an-Event/Global-Oil-Gas-Middle-East-North-Africa-(1) **24-26.**

SPE Hydraulic Fracturing Technology Conference, The Woodlands, Tex., web site: www.spe.org/events/hftc/2017/ **24-26.**

NACE International Pipeline Coating Technology Conference, Houston, web site: pipelinecoating.nace.org/ **24-26.**

Offshore West Africa, Lagos, web site: www.offshorewestafrica.com/index.html **24-26.**

2017 API Inspection Summit, Galveston, Tex., web site: www.api.org/Events-and-Training/Calendar-of-Events/2017/inspection **Jan. 30-Feb 2.**

FEBRUARY 2017

7th Basra Oil & Gas International Conference & Exhibition, Basra, web site: www.basraoilgas.com/Conference/ **8-11.**

NAPE Summit, Houston, web site: napeexpo.com/shows/about-the-show/summit **15-17.**

19th International Conference on Oil, Gas & Petrochemical Engineering (ICOGPE 2017), Venice, web site: www.waset.org/conference/2017/02/venice/ICOGPE **16-17.**

Society of Petroleum Engineers (SPE) Reservoir Simulation Conference, Montgomery, Tex., web site: www.spe.org/events/rsc/2017/ **20-22.**

Australasian Oil & Gas Exhibition & Conference (AOG), Perth, web site: aogexpo.com.au/ **22-24.**

MARCH 2017

Society of Petroleum Engineers (SPE) 20th Middle East Oil & Gas Show & Conference (MEOS), Manama, Bahrain, web site: meos17.com/ **6-9**.

SPE/IADC Drilling Conference & Exhibition, Dublin, web site: www.spe.org/events/dc/2017/ **7-9.**

15th Global Oil & Gas Turkey, Istanbul, web site: www.global-oilgas.com/Turkey/Home/ **15-16.**

SPE/ICoTA Coiled Tubing & Well Intervention Conference & Exhibition, Houston, web site: www.spe.org/events/ctwi/2017/ **21-22.**

Corrosion 2017 Conference & Expo, New Orleans, web site: nacecorrosion.org/ **26-30.**

SPE Oklahoma City Oil & Gas Symposium, Oklahoma City, web site: www.speokcsymposium.org/ **27-31.**

APRIL 2017

AAPG 2017 Annual Convention & Exhibition, Houston, web site: www.aapg.org/events/conferences/ace/ **2-5.**

SPE International Conference on Oilfield Chemistry, Montgomery, Tex., web site: www.spe.org/events/en/2017/conference/17occ/homepage.html/ **3-5.**

SPE Asia Pacific Health, Safety, Security, Environment & Social Responsibility Conference, Kuala Lumpur, web site: www.spe.org/events/en/2017/conference/17aphs/homepage.html/ **4-6.**

Gastech Conference & Exhibition, Tokyo, web site: www.gastech-event.com/ **4-7.**

11th Global Oil & Gas Atyrau Conference, Kazakhstan, web site: www.oilgas-events.com/Oiltech-Atyrau-Conference/ **11-12.**

Neftegaz 2017 17th International Exhibition for Equipment & Technologies for Oil & Gas Industries, Moscow, web site: www.neftegaz-expo.ru/en/neftegaz_2017/ **17-20.**

Society of Petroleum Engineers (SPE) Health, Safety, Security, Environment & Social Responsibility Conference–North America, New Orleans, web site: www.spe.org/events/hsse/2017/ **18-20.**

MAY 2017

Colombia Oil & Gas Conference & Exhibition, Cartagena, web site: 10times.com/colombia-oilgas-exhibition **7-9.**

International Oil Spill Conference, Long Beach, Calif., web site: iosc2017.org/ **15-18.**

SPE Latin America & Caribbean Petroleum Engineering Conference, Buenos Aires, web site: www.spe.org/events/en/2017/conference/17lacp/homepage.html/**17-19.**

JUNE 2017

The 16th Asian Oil, Gas & Petrochemical Engineering Exhibition, Kuala Lumpur, web site: www.oilandgas-asia.com/home/index.php **11-13.**

Brasil Offshore, Rio de Janeiro, web site: www.brasiloffshore.com/en/Home/ **20-23.**

13th Russian Petroleum & Gas Congress (RPGC), Moscow, web site: www.oilgas-events.com/RPGC-Congress/ **27-29.**

14th Moscow International Oil & Gas Exhibition (MIOGE), Moscow, web site: www.oilgas-events.com/MIOGE-Exhibition **27-30.**

JULY 2017

22nd World Petroleum Congress (WPC), Istanbul, web site: www.22wpc.com/ **9-13.**

The 16th Asian Oil, Gas & Petrochemical Engineering Exhibition, Kuala Lumpur, web site: www.oilandgas-asia.com/home/index.php **11-13.**

SEPTEMBER 2017

SPE Offshore Europe Conference & Exhibition, Aberdeen, web site: www.offshore-europe.co.uk/ **5-8.**

Global Oil & Gas Middle East & North Africa Conference, Cairo, web site: www.oilgas-events.com/Find-an-Event/Global-Oil-Gas-Middle-East-North-Africa-%281%29 **17-19**.

Buoy designer misidentified

Our attention was recently drawn to the Oil & Gas Journal Online article "Newly formed Quadrant Energy to decommission East Spar buoy," dated June 23, 2015.

We are highly concerned by the misinformation provided in this article regarding the designer of the East Spar Buoy. This article suggests the designer was the Norwegian group Kvaerner, which is wrong and commercially sensitive since Ocean Resource invented the autonomous buoy concept and holds patents for these.

We have designed, built, installed, and commissioned over 15 of these buoys over the past 30 years, and they have a wide range of application, including offshore oil and gas field support and full production.

Lewis Lack
Business Development Director
Ocean Resource Ltd.
Portskewett, Wales

Saudi spare capacity

Concerning your Apr. 25 Journally Speaking [about deliberation by oil-exporting countries of a production freeze], I think any of us could have predicted the outcome of the Apr. 17 meeting (OGJ, Apr. 25, 2016, p. 16). You are right, you should have gone on record before the event.

I do have a comment on the generally accepted belief that Saudi has 2 million b/d in excess capacity. I have been hearing that Saudi can produce 12 million b/d for over 16 years. I worked in Saudi Arabia in 2000-02, and I do not think that they can produce 12 million b/d. They couldn't for sure then and probably can't now.

In 2006 they were producing 9.5 million b/d, and the OPEC price was $60/bbl. In 2012 they got production to 10.02 million b/d, and then it dropped back to 9.24 million b/d. The price was $109/bbl. If they were capable of 12 million b/d, why didn't they produce it then? They would have claimed greater market share (Iran had just been slapped with sanctions), would have gotten tremendous revenue, and could have dampened the price enough to curtail the unconventional boom that was building in the US.

In spite of hundreds of billions of dollars invested from 2002 to 2015, they were only able to boost production to 10.25 million b/d in June, an all-time maximum. They have to find 750,000-1 million b/d in new production each year just to replace decline.

I love the Arab people and enjoyed my association with them in my work there. I think it is good for them, politically, to have 2 million b/d in spare capacity, just as it was for Saddam Hussein to have nuclear weapons. I think their spare capacity may be just as real as Saddam's nukes were.

W. Todd Lovett
Reservoir Engineer
Amarillo

Climate mantra costs

Concerning "European approach to climate helps explain Trump win" (OGJ, May 16, 2016, p. 27): very nice analysis.

Countries who adopt the climate change mantra without economics will fail. The world cannot subsidize its way to a cooler environment.

If people find value in reducing greenhouse gases, they should be okay paying for it with higher prices. I do not see that happening.

Michael Strathman
The Trinity Group Inc.
Houston


Smart move
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Lost in translations

ROBERT BRELSFORD
Downstream Technology Editor

After nearly 3 years working for Oil & Gas Journal, the current weekly column marks this editor's first to appear in a monthly printed issue. As momentous an occasion as this first time may be for an OGJ editor, it's also as equally nerve-racking.

To see your words dance across the pixelated stage of the digitized screen is one thing. With a single click, you're able send whatever you once had to say waltzing into the outermost limits of your personal cyberspace forever. To have those words sepia-splashed across the space of a physically printed page, though—particularly one between the covers of this long-revered publication—is another thing entirely. It stirs in the writer a desire to say something impactful, inspires him to be self-reflective enough to pull back the curtain and provide an honest, useful glimpse into what life is like behind-the-scenes for the OGJ editors working to deliver the quality news and technical content on which their readers regularly rely.

To become part of the magazine's history, this act of entering its pages—whether digital or print—unquestionably carries with it both an honor and responsibility.

Honor in the sense that not every news release or technology breakthrough will be deemed by editors as important enough to our readership to merit a space.

Responsibility in the sense that, in order even to be considered for a space, the aspiring content needs to be clearly explained, applicable to actual industry operations, and most importantly, made readily accessible to the appropriate news or section editor.

'We released it in Sanskrit in a Tweet'

For this downstream technology editor, an increasingly difficult barrier to pass to make it into the pages of OGJ should be the easiest one of all to overcome: accessibility.

While I have a great many friends in public relations, our career choices naturally discourage too much shoptalk when we're together. After several conversations with company PR contacts at recent conferences, however, I'm tempted to enquire as to what PR classes actually teach these days. The exchanges to which I refer above more or less go something like this:

PR: *"Why didn't OGJ cover our news item?"*
RB: *"You seem to have left us off your notification list."*
PR: *"Oh, it wasn't a formal release. We released it overnight in a post on [pick your choice] Facebook, Twitter, LinkedIn, Instagram, etc."*
RB: *"Strange, it didn't show up on any of my feeds for your social media sites."*
PR: "You mean don't also subscribe to our [again, take your pick] German, Arabic, French, Dutch, Chinese, etc. page?"

For the record, in this editor's opinion, a PR department's elusive maneuvering to make-an-announcement-without-making-an-announcement and not having that announcement picked up is a case of just desserts.

Speaking in tongues

As thorough as I am—and I am thorough—there aren't enough hours in a day to monitor even a single company's myriad English-language social media sites, much less its multiple foreign-language sites. Given the hundreds of downstream operating companies with (oftentimes) individual social media accounts for each plant location, time devoted to the act of constantly monitoring these pages would displace the act of ever actually covering the legitimate news they had to offer.

And let's not even get started on the pitiable whining for coverage from PR departments of companies that refuse to provide English translations of information in these so-called social-media news releases posted in foreign languages. As it is, I spend a good 30% of an average newswriting day undertaking translations of official press releases to ensure accurate news stories for our readers. Enough, as they say, is enough.

If social media sites are intended to enhance a company's PR, perhaps the companies should teach their PR departments how to use them…that, or maybe just how to write a good, old-fashioned press release. OGJ

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Trump's energy speech

Donald Trump broke the seals on three important issues in a speech about energy May 26 in Bismarck, ND. The Republican aspirant to the US presidency sensibly sees the subject as a way to differentiate himself from Hillary Clinton, the probable Democratic candidate. To succeed, however, he'll have to develop his themes to depth uncharacteristic of his campaign.

Trump's first speech dedicated to energy contained the grand promises and bald contradictions his supporters and detractors have come to expect. The US, he said, will become "totally independent of any need to import energy from the OPEC cartel or any nations hostile to our interests." But it will work with Persian Gulf allies toward a "positive energy relationship as part of our antiterrorism strategy." When he promised to use "revenues from energy production" to rebuild schools and transportation infrastructure, was he making a rhetorical point or revealing unwholesome craving for oil-industry cash?

Much more usefully, Trump emphasized the wealth-generating potential of resource development, even citing estimates from a study by the Institute for Energy Research on economic benefits of federal oil, gas, and coal leasing. If he exaggerated in places—nothing new there—he nevertheless made the important point that resource development boosts the economy, employs people, and enriches governments. A corollary, that shunning development imposes painful sacrifice, receives scant notice in liberal circles seduced by notions of "unburnable carbon." The real estate tycoon performed a service by drawing attention to it.

Trump also challenged sacred icons of climate politics. He promised to rescind the Obama administration's Clean Power Plan (which he called the Climate Action Plan), cancel the Paris climate agreement, stop US payments for United Nations global-warming programs, and ask TransCanada to renew its application for the Keystone XL pipeline border crossing. All these proposals have merit. They'd all provoke angry protest from environmental extremists. And they wouldn't go far enough.

Responding to climate change has become a transcendent cause of political liberalism and a priority of energy policy-making. The movement asserts implausible certainty, foments fear, stigmatizes opposition, distorts facts, and manipulates legal systems. And it's succeeding. The Obama administration's rejection of the Keystone XL pipeline border crossing and storm of regulations impeding fossil-energy work testify to its potency.

But repealing laws and revoking executive orders won't stop climate obstructionism. The movement's strategic assertions and statist prescriptions need scrutiny not forthcoming from the political left or media. Having seized extraordinary attention, Trump can deliver overdue challenges if he really understands the subject.

Responding to his newly articulated heresy, defenders of climate faith will demand to know why Trump denies that human activity causes most observed warming, rejects the disastrous predictions of settled science, fails to see that the costs of overhauling energy economies fall below those of inaction, and frets about compromises to market freedom and human liberty. These questions all have compelling answers seldom granted a hearing. Trump should provide them if he can. He should attack not only the climate movement's administrative triumphs but also its strained arguments and hidden agendas. Rescinding the Clean Power Plan would only energize well-organized, well-funded, and persistent advocacy groups. Discrediting them would be better.

Whether by calculation or instinct, Trump introduced a related line of argument in the third breakthrough of his Bismarck speech. "In a Trump administration," he said, "political activists with extreme agendas will no longer write the rules." He referred, of course, to the Environmental Protection Agency, which during the Obama administration has been extraordinarily cozy with pressure groups and dangerously eager to regulate. Trump's comment shines needed light on the subtle tyrannies that develop when activism, which democracy needs in measured doses, migrates from frontiers of change into centers of power.

Trump deserves credit for opening discussion of energy problems too long ignored. But can he move the conversation beyond truculent bluster? The answer will determine whether his "America first energy plan" lives up to its name. OGJ

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Surge in NGL and tight-oil supplies creates worldwide 'light-ends space'

Al Troner
Asia Pacific Energy Consulting
Houston

While many analysts agree that oversupply, rather than weak demand, led to the current slump in the price of crude oil, few have looked closely at the nature of that supply overhang.

In a new study, Asia Pacific Energy Consulting (APEC) has examined in depth the role of NGLs, in particular condensate, in creating the current surplus, as well as the impact of tight oil and its light derivatives.[1] The condensate, other NGLs (LPG and ethane), light products, and tight oil yielding much of the new light-product supply all occupy the same light segment of the hydrocarbon spectrum.

The shale revolution has spurred a ballooning of NGL output, paralleled by dizzying growth in tight oil production. Almost all of this incremental liquids production has been light and sweet. The growing volume of this material, with incremental supply in the millions of barrels per day, has begun to shift pricing, trade, marketing, and supply-demand balances for crude—light-heavy vs. sweet-sour—and in products, with notable supply gains in LPG, gasoline, and naphtha in contrast to middle-barrel and heavy products.

A "light-ends space" is emerging, not only in the US and the Atlantic Basin but also globally, as markets attempt to adjust to this surge in light, low-sulfur hydrocarbon supply.

Focus on condensate

The APEC study focused on the role of condensate as the spearhead creating this light-ends space because it is the only NGL that does not need specialized containment and that, when refined, yields a full range of products, from LPG to residual. Once condensate becomes a liquid it remains a liquid, and in a refinery or condensate splitter acts much like crude in the slate.

Condensate is often confused with light, sweet crude oil, yet it has distinctive characteristics. Unlike crude, condensate always originates with gas, whether nonassociated or associated. Whole condensate almost always yields more than 50% naphtha and is almost always quite clean, low not only in sulfur but also in metals and acid.

It is exceptionally clear, with most containing 0.3% sulfur or less.

Many observers try to define condensate by setting an arbitrary API gravity breakpoint: in the US commonly 45° API, in international trade usually 50° API. But these are rules made to be broken. There are crude grades well above 50° API, such as Saudi Arabia's Super Light and Australia's Laminaria. There are condensate grades under 50° API, such as Kazakhstan's Karachaganak and Nigerian Oso. In defining what constitutes condensate, API gravity is only a general indicator, not an exact test of what is condensate and what is crude.

What is important for condensate is that it always originates in gas, almost always yields 50%+ naphtha, is exceptionally sweet, contains little if any metals, and produces little residual oil. A crude and condensate can have exactly the same API gravity, but the condensate will always yield far more naphtha and far less fuel oil.

The US has emerged as a major NGL power due to the shale revolution. Despite the plateau and then decline of tight oil production in 2016, overall NGL output will continue to rise despite declining condensate volumes produced with tight oil, according to the US Energy Information Administration.

In part this is due to the nature of NGLs, caught in a twilight zone of production parameters. NGLs come from both the crude and the gas sides of total production. And while condensate has been the most prominent NGL derived from gas produced in association with tight oil, plays such as the Eagle Ford shale and Permian basins also have produced sizable volumes of LPG and even commercial volumes of ethane. Yet NGLs also come from primarily nonassociated gas production as well, such as the Marcellus and Utica shales in the US Northeast.

Tight oil production, concentrated in the Bakken, Eagle Ford, and Permian plays, has accounted for much of the US increase in oil production and, together with the Marcellus-Utica developments, condensate output in recent years. All have experienced differing production profiles for conden-

sate in 2016. Overall Eagle Ford production, including condensate, declined sharply by early 2016 and was trending lower toward midyear. Permian crude and condensate production continued to rise, albeit at a diminishing rate, into the year's second quarter. And while Bakken crude output fell sharply, condensate production rose as producers moved to curb gas flaring and strip gas output for NGL flows.

Nationally, propane and butane production continued to rise, mainly on field output, while ethane output used for petrochemicals recorded small volume gains.

A LOOK AT GLOBAL SEGREGATED CONDENSATE SUPPLY

Table 1

	2014	2015	2016	2017	2018	2019	2020	2021
	1,000 b/d							
NORTH AMERICA	823	932	1,044	1,115	1,220	1,268	1,309	1,353
US[1]	574	665	765	810	890	910	925	925
Canada	176	194	204	228	250	276	294	322
Mexico	73	73	75	77	80	82	90	106
EAST OF SUEZ	3,357	3,546	3,751	3,910	4,099	4,264	4,383	4,519
MIDEAST GULF	2,431	2,613	2,790	2,877	2,980	3,133	3,209	3,302
Iran	498	528	624	684	757	781	801	854
Iraq	20	20	23	32	55	88	108	123
Kuwait	—	—	—	—	—	—	20	28
Oman	1	4	8	8	12	20	28	28
Qatar	730	775	800	805	795	785	770	770
Saudi Arabia	730	805	830	840	860	940	955	970
UAE	452	481	505	508	501	519	527	529
Yemen[2]	—	—	—	—	—	—	—	—
ASIA PACIFIC	926	933	961	1,033	1,119	1,131	1,174	1,217
Australia	130	147	158	215	293	297	311	318
Bangladesh	9	12	13	18	18	17	17	16
Brunei	19	19	21	23	25	26	30	35
China	195	197	216	240	253	262	268	271
India	16	16	16	16	16	16	16	16
Indonesia	141	129	115	107	108	113	129	147
Japan	—	—	—	—	—	—	—	—
Malaysia	115	119	137	149	152	152	150	147
Myanmar	27	29	35	35	35	35	34	34
New Zealand	19	22	22	21	19	19	18	17
Pakistan	15	15	15	15	16	16	16	16
Papua New Guinea	1	1	1	2	4	4	12	24
Philippines	14	13	13	13	13	13	12	12
Singapore	—	—	—	—	—	—	—	—
South Korea	—	—	—	—	—	—	—	—
Taiwan	—	—	—	—	—	—	—	—
Thailand	129	132	129	119	113	112	112	112
Timor Leste	54	40	30	20	16	12	10	8
Vietnam	42	42	40	40	38	37	39	44
EUROPE	868	918	994	1,028	1,063	1,129	1,192	1,238
Azerbaijan[3]	—	—	—	—	—	—	—	—
France	—	—	—	—	—	—	—	—
Germany	—	—	—	—	—	—	—	—
Italy	—	—	—	—	—	—	—	—
Kazakhstan	251	255	287	295	310	345	395	405
Netherlands	17	15	15	14	14	13	13	13
Norway	45	48	47	49	49	46	54	60
Russia	555	600	645	670	690	725	730	760
Spain	—	—	—	—	—	—	—	—
UK[3]	—	—	—	—	—	—	—	—
AFRICA	730	695	722	842	931	994	1,055	1,122
Algeria	379	380	390	410	430	445	460	490
Angola	4	—	12	21	24	24	34	44
Egypt	87	89	100	106	115	135	150	155
Equatorial Guinea	115	105	109	153	163	157	149	144
Libya	92	65	55	86	105	136	165	192
Mozambique	4	4	5	5	5	5	5	5
Nigeria	38	41	41	51	75	78	78	78
South Africa	11	11	10	10	14	14	14	14
SOUTH AMERICA	316	350	380	408	444	475	493	506
Argentina	23	32	38	44	52	64	78	94
Brazil	24	26	30	32	32	36	36	36
Colombia	32	38	40	38	34	32	30	28
Peru	66	78	86	96	104	110	112	112
Trinidad	27	26	26	35	54	55	55	54
Venezuela	144	150	160	163	168	178	182	182
TOTAL	**6,094**	**6,441**	**6,891**	**7,303**	**7,757**	**8,130**	**8,432**	**8,738**
US potential[1]	1,247	1,545	1,692	1,759	1,830	1,812	1,803	1,780

[1]Figures in table above are actual production. Figures in bottom line are potential production. [2]No numbers for Yemen due to civil war. [3]No forecasts provided as they do not produce segregated condensate or else use it internally.

A LOOK AT GLOBAL LPG SUPPLY

Table 2

	2014	2015	2016	2017	2018	2019	2020	2021
	1,000 b/d							
NORTH AMERICA	2,143	2,225	2,268	2,401	2,516	2,609	2,677	2,738
US	1,626	1,700	1,730	1,840	1,935	2,010	2,070	2,120
Canada	315	325	336	358	367	377	379	382
Mexico	202	200	202	203	214	222	228	236
EAST OF SUEZ	3,831	3,886	3,985	4,108	4,235	4,320	4,394	4,466
MIDEAST GULF	1,921	1,998	2,067	2,132	2,208	2,278	2,336	2,411
Iran	226	250	285	315	350	380	410	440
Iraq	43	48	54	60	68	84	94	104
Kuwait	110	136	138	140	142	146	150	154
Oman	9	10	12	12	15	15	17	18
Qatar	380	410	410	413	425	430	430	435
Saudi Arabia	867	860	884	905	918	924	922	930
UAE	261	270	272	274	276	285	295	308
Yemen	25	14	12	13	14	14	18	22
ASIA PACIFIC	1,910	1,888	1,918	1,976	2,027	2,042	2,058	2,055
Australia	89	73	80	96	128	140	140	142
Bangladesh	1	1	1	1	1	1	1	1
Brunei	1	6	5	7	8	9	9	9
China	850	795	808	832	839	845	842	840
India	317	326	330	333	335	336	352	352
Indonesia	61	83	84	84	84	87	87	87
Japan	139	134	129	128	129	126	123	119
Malaysia	102	113	117	122	124	124	128	129
Myanmar	1	2	2	2	3	3	3	4
New Zealand	6	6	6	6	6	5	5	5
Pakistan	10	11	13	13	13	13	12	11
Papua New Guinea	2	3	5	5	5	5	5	5
Philippines	9	9	8	8	8	5	5	5
Singapore	30	28	27	29	32	33	33	34
South Korea	67	72	76	81	84	84	86	86
Taiwan	41	42	42	44	46	46	47	48
Thailand	146	148	151	149	147	147	145	145
Timor Leste	19	17	16	14	12	10	9	7
Vietnam	19	19	18	22	23	23	26	26
EUROPE	1,230	1,201	1,235	1,285	1,331	1,399	1,442	1,481
Azerbaijan	8	9	13	16	16	16	18	18
France	47	40	38	35	34	39	42	44
Germany	80	83	83	82	80	78	77	75
Italy	52	57	63	75	76	74	73	72
Kazakhstan	15	15	16	18	20	20	22	23
Netherlands	52	45	45	44	44	44	43	43
Norway	241	252	265	268	270	276	282	288
Russia	573	540	552	589	638	699	736	773
Spain	51	52	54	54	53	53	53	53
UK[2]	111	108	106	104	100	100	96	92
AFRICA	482	490	496	520	533	555	594	607
Algeria	283	286	286	290	294	298	304	310
Angola	21	23	26	30	34	36	42	44
Egypt	55	53	55	59	61	68	74	78
Equatorial Guinea	21	21	21	21	23	30	38	38
Libya	29	35	35	42	42	42	49	49
Mozambique	2	2	2	3	3	3	4	4
Nigeria	57	61	62	65	66	68	69	70
South Africa	14	9	9	10	10	10	14	14
SOUTH AMERICA	421	438	458	482	509	528	542	560
Argentina	87	91	96	102	110	118	128	134
Brazil	179	186	190	196	206	208	212	218
Colombia	21	21	22	22	25	25	25	27
Peru	45	49	51	54	54	54	54	53
Trinidad	22	21	21	26	32	33	33	32
Venezuela	67	70	78	82	82	90	90	96
TOTAL	**8,107**	**8,240**	**8,442**	**8,796**	**9,124**	**9,411**	**9,649**	**9,852**

US product exports

Almost unheralded, the US has emerged as the largest exporter of oil products, based on Gulf Coast refiners' use of relatively inexpensive, domestically produced tight oil. The product-export flood has been paralleled by large-volume NGL sales, with LPG leading the way, in particular propane.

US sales have not only saturated the Atlantic Basin market but also become important to Asia Pacific supply. At mid-2015 China was the biggest single customer for US propane. And the opening of a revamped and enlarged Panama Canal by yearend will likely increase westbound LPG exports from the Gulf Coast even further. By 2018 US exports of LPG exports will likely equal or exceed those of the United Arab Emirates and Qatar combined.

Canada remains the top condensate US export market. APEC expects US supply to dominate Canadian diluent use

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A LOOK AT GLOBAL ETHANE SUPPLY

Table 3

	2014	2015	2016	2017	2018	2019	2020	2021
	1,000 b/d							
NORTH AMERICA	1,396	1,466	1,622	1,888	1,966	2,102	2,152	2,203
US	1,020	1,065	1,175	1,380	1,420	1,540	1,580	1,620
Canada	265	287	307	338	351	358	366	373
Mexico	111	114	140	170	195	204	206	210
EAST OF SUEZ	628	634	655	688	743	820	900	913
MIDEAST GULF	544	552	573	600	629	675	740	748
Iran	25	26	28	40	48	66	90	90
Iraq	—	—	—	—	—	—	—	—
Kuwait	44	44	44	43	43	43	50	56
Oman	—	—	—	—	—	10	30	30
Qatar	150	152	154	154	158	174	178	178
Saudi Arabia	278	280	287	288	300	302	312	314
UAE	47	50	60	75	80	80	80	80
Yemen[1]	—	—	—	—	—	—	—	—
ASIA PACIFIC	84	82	82	88	114	145	160	165
Australia	14	14	14	14	14	13	13	13
Bangladesh	—	—	—	—	—	—	—	—
Brunei	—	—	—	—	—	—	—	—
China	—	—	—	7	15	25	35	40
India	30	30	30	30	50	72	80	80
Indonesia	—	—	—	—	—	—	—	—
Japan	—	—	—	—	—	—	—	—
Malaysia	21	18	18	18	16	16	14	14
Myanmar	—	—	—	—	—	—	—	—
New Zealand	—	—	—	—	—	—	—	—
Pakistan	—	—	—	—	—	—	—	—
Papua New Guinea	—	—	—	—	—	—	—	—
Philippines	—	—	—	—	—	—	—	—
Singapore	—	—	—	—	—	—	—	—
South Korea	—	—	—	—	—	—	—	—
Taiwan	—	—	—	—	—	—	—	—
Thailand	19	20	20	19	19	19	18	18
Timor Leste	—	—	—	—	—	—	—	—
Vietnam	—	—	—	—	—	—	—	—
EUROPE	563	582	585	599	624	662	688	714
Azerbaijan	—	—	—	—	—	—	—	—
France	1	1	1	1	1	1	1	1
Germany	—	—	—	—	—	—	—	—
Italy	—	—	—	—	—	—	—	—
Kazakhstan	—	—	—	—	8	10	15	20
Netherlands	8	7	7	7	6	6	6	6
Norway	42	42	40	40	38	44	46	48
Russia	500	520	525	540	560	590	610	630
Spain	—	—	—	—	—	—	—	—
UK	12	12	12	11	11	11	10	9
AFRICA	13	13	13	13	13	45	60	65
Algeria	13	13	13	13	13	45	60	65
Angola	—	—	—	—	—	—	—	—
Egypt	—	—	—	—	—	—	—	—
Equatorial Guinea	—	—	—	—	—	—	—	—
Libya	—	—	—	—	—	—	—	—
Mozambique	—	—	—	—	—	—	—	—
Nigeria	—	—	—	—	—	—	—	—
South Africa	—	—	—	—	—	—	—	—
SOUTH AMERICA	82	88	89	105	122	135	147	157
Argentina	55	62	65	80	95	110	120	132
Brazil	9	8	8	9	11	11	13	13
Colombia	2	2	2	2	2	2	2	2
Peru	—	—	—	—	—	—	—	—
Trinidad	—	—	—	—	—	—	—	—
Venezuela	16	16	14	14	14	12	12	10
TOTAL	**2,682**	**2,783**	**2,964**	**3,293**	**3,468**	**3,764**	**3,947**	**4,052**

[1]No numbers for Yemen due to civil war.

until at least end-decade. Yet domestic condensate output has been growing rapidly in Canada, based on tight oil and shale gas development, in a trend APEC expects will gradually back out US sales in the coming decade. A steadier though smaller market emerged for slightly refined condensate in Europe, where refiners use the material regularly to fill out crude slates. By 2018 US condensate exports will exceed overseas sales by Saudi Arabia, and possibly by the kingdom and Qatar combined.

Ethane exports have begun as US sellers pioneered waterborne ethane shipments to buyers in the UK, Norway (Ineos and Sabic), and Sweden (Borealis). This has been followed by sales to India (Reliance) and China (Orient Energy).

The emergence of the light-ends space has not been solely

A LOOK AT GLOBAL NGL SUPPLY

Table 4

	2014	2015	2016	2017	2018	2019	2020	2021
	1,000 b/d							
NORTH AMERICA	4,362	4,623	4,934	5,404	5,702	5,979	6,138	6,294
US	3,220	3,430	3,670	4,030	4,245	4,460	4,575	4,665
Canada	756	806	847	924	968	1,011	1,039	1,077
Mexico	386	387	417	450	489	508	524	552
EAST OF SUEZ	7,816	8,066	8,391	8,706	9,077	9,404	9,677	9,898
MIDEAST GULF	4,896	5,163	5,430	5,609	5,817	6,086	6,285	6,461
Iran	749	804	937	1,039	1,155	1,227	1,301	1,384
Iraq	63	68	77	92	123	172	202	227
Kuwait	154	180	182	183	185	189	220	238
Oman	10	14	20	20	27	45	75	76
Qatar	1,260	1,337	1,364	1,372	1,378	1,389	1,378	1,383
Saudi Arabia	1,875	1,945	2,001	2,033	2,078	2,166	2,189	2,214
UAE	760	801	837	857	857	884	902	917
Yemen[1]	25	14	12	13	14	14	18	22
ASIA PACIFIC	2,920	2,903	2,961	3,097	3,260	3,318	3,392	3,437
Australia	233	234	252	325	435	450	464	473
Bangladesh	10	13	14	19	19	18	18	17
Brunei	20	25	26	30	33	35	39	44
China	1,045	992	1,024	1,079	1,107	1,132	1,145	1,151
India	363	372	376	379	401	424	448	448
Indonesia	202	212	199	191	192	200	216	234
Japan	139	134	129	128	129	126	123	119
Malaysia	238	250	272	289	292	292	292	290
Myanmar	28	31	37	37	38	38	37	38
New Zealand	25	28	28	27	25	24	23	22
Pakistan	25	26	28	28	29	29	28	27
Papua New Guinea	3	4	6	7	9	9	17	29
Philippines	23	22	21	21	21	18	17	17
Singapore	30	28	27	29	32	33	33	34
South Korea	67	72	76	81	84	84	86	86
Taiwan	41	42	42	44	46	46	47	48
Thailand	294	300	300	287	279	278	275	275
Timor Leste	73	57	46	34	28	22	19	15
Vietnam	61	61	58	62	61	60	65	70
EUROPE	2,661	2,701	2,814	2,912	3,018	3,190	3,322	3,433
Azerbaijan	8	9	13	16	16	16	18	18
France	48	41	39	36	35	40	43	45
Germany	80	83	83	82	80	78	77	75
Italy	52	57	63	75	76	74	73	72
Kazakhstan	266	270	303	313	338	375	432	448
Netherlands	77	67	67	65	64	63	62	62
Norway	328	342	352	357	357	366	382	396
Russia	1,628	1,660	1,722	1,799	1,888	2,014	2,076	2,163
Spain	51	52	54	54	53	53	53	53
UK	123	120	118	115	111	111	106	101
AFRICA	1,083	1,056	1,076	1,210	1,301	1,391	1,485	1,561
Algeria	675	679	689	713	737	788	824	865
Angola	25	23	38	51	58	60	76	88
Egypt								
Equatorial Guinea	136	126	130	174	186	187	187	182
Libya	121	100	90	128	147	178	214	241
Mozambique	6	6	7	8	8	8	9	9
Nigeria	95	102	103	116	141	146	147	148
South Africa	25	20	19	20	24	24	28	28
SOUTH AMERICA	819	876	927	995	1,075	1,138	1,182	1,223
Argentina	165	185	199	226	257	292	326	360
Brazil	212	220	228	237	249	255	261	267
Colombia	55	61	64	62	61	59	57	57
Peru	111	127	137	150	158	164	166	165
Trinidad	49	47	47	61	86	88	88	86
Venezuela	227	236	252	259	264	280	284	288
TOTAL	**16,741**	**17,322**	**18,142**	**19,227**	**20,173**	**21,102**	**21,804**	**22,409**

[1]No field production of NGLs, but production number represents refinery LPG output only.

a western market phenomenon. It has had East of Suez impacts as well, much of it centered on the Persian Gulf.

East of Suez

Iran and the US have emerged as the two main drivers of condensate supply through the medium term, and both could be exporting substantially increased volumes by 2018 (Table 1).

The Islamic Republic has long been a major condensate exporter, but progressively tightening sanctions cut deeply into Iranian sales abroad while a lack of project investment slowed the long-anticipated expansion of South Pars field condensate and LPG output.

Iran's condensate prospects hinge on the speedy removal of economic sanctions and a fast-track program to complete long-delayed gas developments. Immediate impacts of easing sanctions included the disposal of 20-30 million bbl of condensate in floating storage. South Korea and Singapore emerged as major buyers, supplementing China and India, while Japan took experimental cargoes, being cautious about the quality of condensate that had sat in storage for months.

Yet overall so far, Iran has made only limited progress in reversing years of sector neglect. In the first half of 2016 Iran added about 350,000 b/d of liquids production. Of that, only about 35,000 b/d was condensate, although the latter rate should more than double with the start-up of a South Pars phase in the third quarter. By end-2016 APEC expects Iranian production to rise by roughly 500,000 b/d over the previous year's level, with nearly 100,000 b/d of that condensate.

Qatar has the most to lose from a freeing of Iranian marketing. The tiny emirate had a lock-hold over Asian markets that needed large condensate volumes and could not import the material from Iran. This will add considerable pressure on Qatar International Petroleum Marketing Co. (Tasweeq) to reshape its condensate marketing program. Only these two producers are capable of selling condensate in large amounts in the East of Suez market. Unlike Iran, Qatar does not have black oil as a back-up export.

Investment in Iran

Foreign companies are moving cautiously on Iranian investment, upstream and downstream, with legal guidelines and financing regulations still unclear. National Iranian Oil Co. (NIOC) and National Petrochemical Corp. (NPC) plan a massive expansion of Iranian condensate-processing capacity, using condensate splitters and petrochemical pretreatment units.

Official plans call for the completion of nine more condensate splitters, in the Persian Star and Siraf projects, with working capacity totaling 828,000 b/d. This is in addition to the 258,000 b/d of working capacity at six sites operating as of January this year. What's more important, the first part of a three-unit splitting complex, the long-delayed Persian Star, will be commissioned by the second half of 2016. While targeted start-up dates almost certainly are overly ambitious—Siraf is slated to add 480,000 b/d in eight 60,000-b/d units by 2019—it is clear that Iran's condensate processing capacity will soon exceed that of other Gulf producers combined and that the plants will produce enormous volumes of condensate outturn, mainly naphtha.

However, the intent in using this expanded splitter capacity is very different from the ongoing US splitter campaign. Since 2015 the US, mainly on the Gulf Coast, has added five condensate splitters with capacity totaling 309,000 b/d, all aimed at export sales. NIOC has claimed that by end-decade, with the completion of currently planned condensate splitters, the country will have no condensate to export, despite a strong build-up in condensate production. Iran will produce over 800,000 b/d of condensate by 2021, yet Tehran's goal is to use all of this output—in particular the naphtha-gasoline outturn potential—for home-market needs.

Even if this goal of diverting condensate into domestic use succeeds only partially, there is little other new condensate output due to emerge through 2018 in East of Suez markets. In the short term, the direction and volume of US exports will be shaped by the price differential between Brent and West Texas Intermediate crudes as well as the opening of an expanded Panama Canal.

Structural change

In Asia Pacific, only Australia will contribute significantly to incremental condensate output. Multiple projects will add segregated condensate output—but only toward end-decade. Of particular significance is Ichthys, which will likely equal, if not exceed, output from the Northwest Shelf.

The APEC study sees, as a pivotal structural change, the emergence of a "Yin-Yang" of a US light hydrocarbons long position, underpinned by massive NGL output moving to Asia Pacific, complemented by Asia's desire to limit its dependence on Mideast crude, refinery products, and NGLs.

APEC expects US condensate exports to Asia Pacific to grow rapidly once sellers adjust their condensate blends to Asian petrochemical needs. This will represent strong competition to both Iran and Qatar, with US export rates on the order of 200,000 b/d. Asian buyers will soon have a wide range of suppliers possibly discounting to retain market share. Of course US exports of other NGLs, light products, and even tight oil will increase total sales (Tables 2-4).

Dominating Asian condensate demand will be South Korea, which will continue to increase its lead as the region's top condensate processor. The start-up of additional splitters will have the country capable of processing over 700,000 b/d of condensate through splitters as well as running condensate in conventional refineries. South Korea overtook Beijing as the top Asian condensate user by 2013 and has made cross-integration of condensate processing and petrochemicals a major plank of export sales.

China remains a market paradox. Expansion plans for condensate splitting have been suspended as the central government reevaluates all new downstream projects. The shutdown of Dragon Aromatics has actually reduced splitting capacity in this market, though it is likely that Sinopec will take over the now-shuttered complex and operate the splitter with side-by-side petrochemical aromatics units by 2017.

Singapore and India have emerged as major condensate import markets, both for splitting but more importantly for crude blending. India is strategically placed for short-haul sales from the Persian Gulf and is expected to sharply increase its Iranian imports in the medium term.

Japan has remained a major condensate user, but volumes have been static in recent years—a reflection of the essentially stagnant Japanese market. Together with much smaller Thailand, these markets remain important but not key for new condensate sales.

The big picture remains the same. The emergence of the light-ends space has been paralleled in Asia by a shift in demand focus from middle distillates to lighter products. US NGLs have already made considerable inroads into Asian markets and ultimately will present a long-term marketing challenge to Mideast exporters: Who gains the future demand growth of Asia Pacific? OGJ

Reference

1. The full study, East Meets West, can be purchased from PennEnergy at http://ogjresearch.stores.yahoo.net/condensate-east-meets-west.html.

The author

Al Troner is president of Asia Pacific Energy Consulting. He has worked in Asia's energy sector since 1984, when he established Dow Jones/Telerate's regional energy services. He moved to Singapore in 1989 to found and then direct Petroleum Intelligence Weekly's Asia-Pacific bureau. He was the cowinner of the International Association for Energy Economics award for Energy Journalism in 1994, retiring from journalism the following year to found APEC.

During 1987-89, he was a research assistant for the energy group of the East-West Center. Troner has worked in the energy industry in the US, Europe, North Africa, and Middle East, as well as in Asia Pacific.

US House passes amended energy policy bill, sets up joint conference

Nick Snow
Washington Editor

The US House approved an amended version of energy policy reform legislation that the US Senate previously approved, setting the stage for a joint conference to reconcile differences and prepare a final version that would be sent to US President Barack Obama to be signed into law.

The amended Senate bill passed on May 25 by 241 to 178, largely along party lines. Eight Democrats joined Republicans in supporting its passage, while six Republicans joined Democrats in opposing. Fourteen members—six Republicans and eight Republicans—did not vote.

"It has been nearly a decade since we last considered an energy package like this," Energy and Commerce Committee Chairman Fred Upton (R-Mich.) said as final debate began. "This has been a multiyear, multi-Congress effort, and a lot of work has gone in to make sure that the bill that we put forward to support the future of American energy is truly comprehensive."

The amended measure includes elements from HR 8, which Upton initially introduced in December 2015, that include streamlined federal reviews for proposed interstate natural gas pipelines and liquefied natural gas export facilities, and protections for critical energy infrastructure from extreme weather and cyber threats.

Rep. Bobby Rush (D-Ill.), the committee's Ranking Minority Member, disagreed. "This 800-page hodgepodge of Republican and corporate priorities is nothing more than a majority wish list of strictly ideological bills, many of which the minority party opposes and the Obama administration and the American people do not support," he said.

House Speaker Paul D. Ryan (R-Wis.) appointed Upton and 12 other Energy and Commerce Committee Republicans to help lead House negotiators in the upcoming conference with the Senate, the committee announced on May 26. They include Energy and Power Subcommittee Chairman Ed Whitfield (Ky.), Environment and the Economy Subcommittee Chairman John M. Shimkus (Ill.), and Chairman Emeritus Joe Barton (R-Tex.).

"This effort is about jobs. It's about keeping energy affordable. It's about boosting our energy security, here and across the globe," Upton said. "I look forward to working with my colleagues in the Senate and my friends across the aisle to enact meaningful reforms that truly make a difference for folks in Michigan and across the country."

An American Petroleum Institute official promptly applauded the House's action. "Today marks another critical step by Congress to enact a comprehensive energy package that reflects America's new energy reality," API Executive Vice-Pres. Louis Finkel said on May 25. "The US is now the world's leading producer of oil and gas, and we need a forward-looking energy policy if we are to remain an energy superpower and maintain global competitiveness." OGJ

Report calls for independent offshore oil and gas safety organization

Nick Snow
Washington Editor

A report issued by the National Academies of Science, Engineering & Medicine called on the US oil and gas industry to establish an independent organization dedicated to offshore safety and environmental protection, with no advocacy role.

The report suggested that the Center for Offshore Safety, which the American Petroleum Institute and other industry groups formed after the 2010 Macondo deepwater well blowout and crude oil spill in the Gulf of Mexico, could be made independent to serve this purpose. All organizations working in the US offshore oil and gas industry could be required to join, it said.

It said that about 75 well operators, 17 drilling contractors, and more than 1,000 service and supply contractors and subcontractors varying in size and financial resources support offshore drilling, production, and construction activities in the gulf.

Because of differing safety perspectives and economic interests, offshore oil and gas firms do not all belong to a single industry association that speaks with one voice regarding safety, the May 23 report said.

Several challenges exist in setting and implementing consistent goals for safety practices and culture, including organization leaders' varied commitments to having a strong safety culture, the variety of organizations that may work on a single drilling site, making practices such as supervision and training more heterogeneous, and the diversity of employees' safety attitudes and educational backgrounds, it indicated.

"Because the industry is fragmented, it is necessary to work with a coalition of key stakeholders," the report said. "Compliance by itself is insufficient; proactive collective action is needed from a coalition of willing parties. This is especially likely to be the case in the offshore oil and gas industry given the sheer number of groups charged with its operation and the regulators' limited ability to impose changes."

Use available resources

Companies' senior leaders should ensure that their organizations take advantage of resources available from other companies, industry associations, and regulators in strengthening their own safety cultures, it recommended. "Smaller companies can reach out to their larger customers or industry groups to obtain information on establishing or strengthening safety culture and to learn of success stories from those who have created a safe working environment," it said.

It also urged industry leaders to encourage collective and collaborative action to make changes in the fragmented offshore industry. "A starting point is to engage personally and encourage key employees to participate in industry organizations, conferences, benchmarking opportunities, standards-setting groups, pilot projects, and exchanges of information and lessons learned," it said.

The report said leaders from API and the Independent Petroleum Association of America, the International Association of Drilling Contractors, the Society of Petroleum Engineers, the International Association of Oil & Gas Producers, the Center for Offshore Safety, and other groups should join with leaders from the US Bureau of Safety and Environmental Enforcement, the US Coast Guard, and the US Pipeline and Hazardous Material Safety Administration early in the process.

It would help to have a focal organization that is sufficiently independent and can engage the entire industry," the report noted. "There is an opportunity for BSEE and other regulators to provide encouragement and leadership, but demands from a regulator are likely to be met with resistance from the industry. Regulators can help convene senior industry leaders and experts to craft a vision, provide feedback and encouragement, reinforce well-intentioned actions, and coach from the sidelines," it said.

The report also recommended that:

- The industry as a whole make use of offshore safety culture knowledge and experiences of organizations that are moving ahead already and trying new approaches.
- The industry overall create additional guidance for establishing safety culture expectations and responsibilities among operators, contractors, and subcontractors.
- The industry work with regulators to consider changes in policy (and laws when necessary, such as modifying any that inhibit information flow between operators and contractors) that would help accelerate safety improvements, including information exchanges, cooperation across operators and contractors, and protection of all personnel from retaliation if they speak up.
- Regulators and industry participants work to facilitate research and information sharing on ways to share industry-level data more fully, analyze positive cases, define what factors matter most, and systematically study safety improvements among offshore oil and gas companies of all sizes.

"Successful culture change is a long-term effort, entailing considerable uncertainties and investments," said Nancy Tippins, principal consultant at CEB and chair of the committee that conducted the study and wrote the report. "It is essential that industry and regulators go beyond ideas and

possibilities, and develop concrete plans for creating a commitment to a culture that establishes and maintains a safe working environment."

Copies of the full report are available online from the National Academies Press at www.nap.edu/catalog/23524/strengthening-the-safety-culture-of-the-offshore-oil-and-gas-industry. OGJ

WoodMac: UKCS decommissioning to ramp up over next 5 years

Research and consultancy firm Wood Mackenzie Ltd. estimates based on current crude oil prices that 142 fields will cease production and £55 billion will be spent on decommissioning on the UK Continental Shelf over the next 5 years.

The tally includes the removal of 340 platforms with a combined weight of 5.6 million tonnes, and more than 3,000 development wells. Operators of five fields thus far in 2016 have reported their intention to cease production, and WoodMac believes the figure could rise to 50 fields, with many expected to enter "lighthouse mode" to save the imminent decommissioning costs.

The firm notes that 126 UK fields have already ceased but only 27% of those fields have been fully abandoned. Based on the 34 fields classed as abandoned, the average time between cessation of production (COP) and abandonment completion is about 3 years, but this is expected to lengthen as larger developments such as Brent are decommissioned.

"Although decommissioning in the North Sea has been an impending reality for some time, the high oil price between 2011-14 allowed some mature, high-cost fields to keep producing economically," explained Ian Thom, WoodMac senior research manager, UK upstream research.

"The lower-for-longer oil price environment compounded by the maturity of the basin means that continuing production of certain fields in the North Sea region is no longer viable," Thom said. "We expect companies will not be able to keep producing UK fields at a loss, and decommissioning activity will ramp up as a result."

Thom said there are a number of uncertainties in the UKCS decommissioning activity, including the timing of COP and abandonment spending, and the decision to operate at a loss vs. deferring abandonment expenditure in the current environment. Furthermore, a change in mindset will be required to facilitate cooperation among the UKCS companies—something he said will be essential if the decommissioning task ahead is to be done efficiently.

WoodMac explains that recent tax changes introduced in UK Budget 2016 did little to improve company cash flows with so few currently in a tax paying position, but it does improve valuations. This may encourage new investment, or, at the very least, the continuation of loss-making operations over the short term rather than early cessation of fields.

Investment in ageing infrastructure will prevent a domino effect of fields ceasing in this mature sector. If no further investment materializes, the firm warns, the future of the North Sea could hang in the balance. To be sure, many other countries will be watching how the UK oil and gas industry leads the great global decommissioning challenge. OGJ

Rystad Energy: Improving oil prices could help shrink DUC inventory

Paula Dittrick
Upstream Technology Editor

The heart of the Denver-Julesburg (DJ) basin exhibits the most commercial drilled but uncompleted (DUC) backlog, said a Rystad Energy study that estimated the DUC inventory in Weld County, Colo., was economic to complete at an average light, sweet crude oil futures price of $30/bbl.

Other counties that exhibit favorable economics are Reeves County, Tex., in the Permian basin's Delaware and McKenzie County, ND, in the Bakken formation, said Artem Abramov, Rystad senior analyst in Oslo. He believes much of the US shale DUC inventory is commercial given current oil prices.

"Significant support to the US Lower 48 oil supply can be expected in the near months as market sentiment gradually moves in a positive direction," Abramov told OGJ.

Weld County topped Rystad's DUC ranking list by inventory size with almost 600 oil wells awaiting completion crews.

Intentional completion delays by Anadarko Petroleum Corp. accounted for much of the Weld County DUC inventory. Anadarko operates almost half of the DUCs in Weld County. PDC Energy, Noble Energy Inc., and Whiting Petroleum Corp. each operate about 10% of the Weld County DUC inventory, Rystad Energy said.

Hydraulic fracturing is the most cost-intensive part of shale well completions. Economics vary considerably across a play.

For example, the Permian basin represents a collection of some outstanding acreage positions such as the Northern Wolfcamp acreage. But it also has less prospective drilling spots, which are now far from commerciality threshold.

Within the Permian, Delaware acreage exhibits slightly better well economics than Midland acreage.

In the DJ basin, the DUC inventory is concentrated in the basin's core, Weld County. Anadarko intentionally delayed completions primarily during the second half of 2015 because the company had a strong balance sheet and was financially able to wait until commodity prices improved.

"Essentially, these wells were not delayed because it was uncommercial to complete them as it was the case in some other plays," Abramov said. "However, as we entered 2016 with an extremely low price environment, the company decided to focus on completing these DUCs rather than new drilling because a significant part of new drilling turned uncommercial."

During this year's first quarter, Anadarko completed 46 DUCs and drilled only 26 new wells so the DUC inventory started going down.

"The trend is likely to persist in the second quarter 2016," Abramov said. "The pace of the DUC inventory contraction is likely to accelerate as we are already at the $45-50/bbl crude oil price level. DUCs will provide a significant support to the US shale oil production." OGJ

Hydraulic fracturing stymied in Canadian East

Hydraulic fracturing remains stymied in two of Canada's Atlantic provinces.

New Brunswick has extended indefinitely a moratorium on the completion technique imposed in 2014.

And an independent panel appointed that year to assess hydraulic fracturing in Newfoundland and Labrador has refused to endorse the method.

New Brunswick moratorium

In New Brunswick, Energy and Mines Minister Donald Arseneault said five conditions the province established for fracing have not been satisfied. The conditions call for:

- A "social license."
- "Clear and credible information" about effects of hydraulic fracturing on public health, the environment, and water "allowing the government to develop a country-leading regulatory regime with sufficient enforcement capabilities."
- A plan to mitigate impacts on public infrastructure and to address issues such as wastewater disposal.
- A process to respect the duty of the provincial government to consult with First Nations (aboriginal groups).
- A mechanism "to ensure that benefits are maximized for New Brunswickers, including the development of a proper royalty structure."

Arseneault said, "It is clear to us that the industry has not met the conditions." With oil and gas prices low, the industry, he added, is unlikely to "invest the necessary efforts to address the conditions in the short or medium term."

Extension of the moratorium responded to findings released in February of the New Brunswick Commission on Hydraulic Fracturing, which was established in March 2015 to determine feasibility of satisfying the conditions.

The Canadian Association of Petroleum Producers issued a statement expressing disappointment with extension of the moratorium.

The group said it provided the commission a written submission addressing the conditions.

Newfoundland and Labrador

In its final report, the Newfoundland and Labrador Hydraulic Fracturing Review Panel, which examined socioeconomic and environmental implications of fracing in western Newfoundland, recommended the province extend its "pause" in the acceptance of applications.

"The panel unanimously recommends that a number of gaps and deficiencies must be addressed before the necessary conditions could exist that would allow for hydraulic fracturing, as an all-inclusive industrial process, to proceed reasonably and responsibly in western Newfoundland," it said.

The panel made 85 supplementary recommendations that it said "constitute a staged, cautious, and evidence-based approach to understanding the opportunities and challenges of unconventional oil and gas development in western Newfoundland."

Implementation of the recommendations, it said, "should allow for a better-informed decision with respect to whether hydraulic fracturing operations should be permitted in the future." OGJ

BSEE, BOEM issue Southern California OCS well-stimulation analysis

Nick Snow
Washington Editor

A comprehensive environmental analysis (EA) of 23 offshore oil and gas platforms operating on the US Outer Continental Shelf off Southern California found no significant impact from the use of well stimulation treatments (WST) there, the US Bureau of Safety and Environmental Enforcement and the Bureau of Ocean Energy Management jointly reported.

The evaluated treatments included fracturing and nonfracturing treatments, which may be used to enhance production from existing or new wells where formation permea-

bility and falling reservoir pressure are limiting oil recovery, according to the Programmatic Environmental Analysis prepared by Argonne National Laboratories.

Four WSTs were evaluated:

• Diagnostic fracture injection test (DFIT), which is used to estimate key reservoir properties and parameters that are needed to optimize a main fracture job.

• Hydraulic fracturing, which involves injection of fracing fluid at a pressure (typically determined by a DFIT) necessary to induce fractures within the producing formation.

• Acid fracturing, which is similar to hydraulic fracturing except that instead of using a proppant to keep fractures open, an acid solution is used to etch channels in the rock walls of the fractures, thereby creating pathways for oil and gas to flow to the well.

• Matrix acidizing, a nonfracing treatment in which an acid solution injected into a formation where it penetrates pores in the rock to dissolve sediments and muds, opening existing channels to allow formation fluids (oil, gas, and water) to move more freely to the well. Matrix acidizing also removes formation damage around a wellbore, which also aids oil flow into the well, the programmatic EA said.

The two US Department of the Interior agencies conducted the EA under settlement agreements regarding their compliance with the National Environmental Policy Act, Outer Continental Shelf Lands Act, and Coastal Zone Management Act. Pending completion of the EA, BSEE agreed to withhold approvals of future drilling permits and permits to modify WSTs involving hydraulic fracturing and other well stimulation treatments on the OCS off Southern California.

Under the agreements, BSEE agreed to develop a mechanism to increase transparency in the permit approval process, as well as a method to alert the public of newly submitted complete permit applications for hydraulic fracturing or acid well stimulation. The programmatic EA will provide the agency's Pacific Region with valuable information as it considers future WST applications, it said.

In their Finding of No Significant Impact concerning their proposal to allow WSTs to be used on the OCS off Southern California, the agencies said that potential adverse impact appeared insignificant. "In some cases where impacts are somewhat more pronounced, such as with discharge of produced water, the impacts are minor, short-term and localized," they added.

BSEE and BOEM also considered:

• The degree to which the proposed action could affect public health and safety.

• Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

• The degree to which the effects on the quality of the human environment are likely to be highly controversial.

• Whether possible effects on the human environment are highly uncertain or involve unique or unknown risks.

• Whether allowing use of these WSTs would establish a precedent for using others or represents a decision about a future consideration.

• Whether the action is related to other actions with individually insignificant but cumulatively significant impacts.

• The extent to which districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places may be affected, or significant scientific, cultural, or historical resources may be lost or destroyed.

• The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the 1973 Endangered Species Act.

• Whether the action potentially violates federal, state, or local environmental protection laws and requirements.

BSEE and BOEM said they received more than 10,000 comments on the draft assessment during the 30-day public comment period that ended on Mar. 23. After reviewing those comments, the bureaus revised the final programmatic EA's text where appropriate, including amending the statement of purpose and need, clarifying the descriptions of alternatives, and adding information on greenhouse gases and climate change.

The evaluated offshore resource area environmental impacts included water quality changes from discharges of produced water, and the potential for associated impacts to fish and wildlife, they indicated.

Considering the low expected concentrations of well stimulation treatment chemicals and the protective nature of the EPA's National Pollutant Discharge Elimination System General Permit and required monitoring of aquatic life, the analysis in the EA affirms that wastewater discharges from proposed well stimulation activities will not have a significant impact on the environment, BSEE and BOEM said.

Accidental releases of well stimulation treatment fluids have a relatively higher potential to have consequence, but the probability of an accident occurring and the reasonably foreseeable size of a resulting release are so small that such accidents would not be expected to cause a significant impact, they added.

Responding to the agencies' announcement, National Ocean Industries Association Pres. Randall B. Luthi said it confirms what the offshore oil and gas industry already knows—that there are no significant impacts from offshore well stimulation treatments.

"We hope this report quickly ends the moratorium on well stimulation techniques offshore California," he said. "The sooner operations can resume [there], the better." OGJ

COGCC outlines impacts if voters approve proposed mandatory setback

Nick Snow
Washington Editor

Ninety percent of Colorado's surface acreage would be off-limits to future oil and gas development or hydraulic fracturing under a November ballot initiative that would establish a minimum 2,500 ft mandatory setback from any "occupied structure" or "area of special concern," the Colorado Oil & Gas Conservation said in a May 27 report.

"In the top 5 producing counties, 95% of the surface area would be within mandatory setback zones and unavailable for new oil and gas development or [fracing] operations," the 20-page COGCC staff analysis said. "The ballot initiative language does not provide any exceptions to or possibility of variance from the mandatory 2,500 ft setback distance."

In Colorado's top five producing counties—Weld, Garfield, La Plata, Rio Blanco, and Las Animas—more than 10.1 million acres would be off-limits, the report said. "Eighty-five percent of surface acreage in Weld County—the state's largest oil and gas producing county—would be unavailable for new oil and gas development facilities or [fracing] operations," it noted.

"This report and map from the state is the smoking gun that antioil and gas activists have been trying to hide," Colorado Oil & Gas Association Pres. Dan Haley said in response to the report's release. "It clearly shows that activists aren't trying to protect neighborhoods or homeowners, but are simply pushing an extreme agenda to end an industry that 5 million Coloradans rely on every day. Any reasonable person can look at this map and see they're advocating for a statewide ban."

Colorado Petroleum Council Executive Director Tracee Bentley agreed. "The COGCC maps prove this setback proposal is short-sighted and reckless," she said in a separate May 27 statement. "Robust regulations exist in the state for oil and gas development and to ensure environmental protection."

Current statewide setback regulations were created in 2013 through a COGCC-led stakeholder process consisting of meetings over several months, and allow for responsible development of oil and gas to exist at least 500 ft from homes and buildings, Bentley noted. "Proposals like this seek to disregard the well thought out stakeholder process that Colorado is known for," she said. "Interfering with this effective system would undermine a crucial source of income for both the state GDP and individual families."

What proposal would do

The proposal, Initiative 78, would add a 30th article to the state constitution requiring that any new oil and gas development facilities, including reentry into a previously abandoned well, would have to be at least 2,500 ft from an occupied structure or area of special concern.

It is one of four, for which signatures are being collected through Aug. 3 for inclusion on the November ballot, which would affect oil and gas operations in the state, COGCC Director Matt Lepore said at an Apr. 18 hearing.

Initiative 78 defines occupied structure as "any building or structure that requires a certificate of occupancy, or building or structure intended for human occupancy, including homes, schools, and hospitals."

An area of special concern would include "public and community drinking water sources, lakes, rivers, perennial or intermittent streams, creeks, irrigation canals, riparian areas, playgrounds, permanent sports fields, amphitheaters, public parks, and public open space."

Additional authority

Section 4 of the proposal would give the state and local governments authority to establish larger setbacks. "In the event that two or more local governments with jurisdiction over the same geographic area establish different setback distances, the larger setback shall govern," it says.

Of the initiative's two featured categories, areas of special concern would have the bigger impact, the COGCC report said. A 2,500-ft setback in that category would put 89% of surface land in the state off-limits to oil and gas development, while the calculated estimate for occupied structures is 22%, it indicated. "In Weld County, the proposed setback requirement from an 'Occupied Structure' [would] potentially make more than 40% of the land unavailable," it added.

"In those areas defined as off-limits to drilling, which is a vast majority of the state with oil and gas resources, lie the property rights of tens of thousands of Coloradans," Haley said. "Those constitutionally protected mineral rights would be shredded by this initiative and would prompt thousands of lawsuits against the State of Colorado for billions of dollars.

"It's just another reason why land use regulations do not belong in the state constitution and why we need to reject these extreme measures that are trying to solve issues that are best left to robust discussions in town halls, city councils and statehouse committee rooms," he said. OGJ

New bid round accelerates Mexico's shale potential

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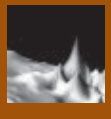
Mexico's shale industry may find traction in 2016. Well-prepared early movers will bid on the choicest geologic areas in one of the most anticipated shale offerings of recent years.

Development hasn't occurred as quickly as expected. Not only were early Petroleos Mexicanos (Pemex) shale wells meager producers, they also were expensive to drill and frac. Despite the disappointing start, Mexico's geologic and commercial qualities could thrust the country to the front of the emerging global shale market.

Low oil prices delayed the country's first shale auction, originally scheduled for last year and designed to attract needed foreign investment and technology. But it could take place later this year or in 2017.



Recognizing its vast shale resources, Mexico's government is opening the country's most prospective acreage, formerly the exclusive domain of Pemex, to foreign capital and expertise. The opening of Mexico's onshore and offshore basins to foreign investment for the first time in 75 years is a key part of the country's ongoing reforms.

Mexico's resource potential ranges from mature onshore fields to rank deepwater settings, including conventional and unconventional reservoirs. The country's upstream renaissance will continue to be an area of interest for the global oil and gas industry.

Delayed development

Mexican regulator National Hydrocarbons Commission (CNH) has not yet announced a revised schedule for Round 1 of its unconventional shale lease. Industry interest has been growing steadily despite the delay, along with an appreciation of Mexico's shale geology.[1]

The macro outlook for shale is also improving, with more than $10 billion invested in pipeline construction and a burgeoning cross-border trade in oil and gas, as US and Mexico move to integrate their refining and marketing systems. Secretaria de Energia de Mexico (Sener) announced 11 pipeline projects totaling 2,300 km and costing $5.2 billion to be built 2014-15 (OGJ Online, May 29, 2014). The recent US Department of Commerce decision to allow crude oil swaps with Mexico is another sign of the countries' closer energy integration (OGJ Online, Aug. 24, 2015).

Favorable geology

Mexico's shale geology appears prospective, especially in identified sweet spots. Stratigraphy will be familiar to North American geologists, particularly those working the Gulf Coast, because the two principal shale targets in Mexico are stratigraphic equivalents of major source rocks and productive shales in the US. Northern Mexico hosts the southern portion of the greater Gulf of Mexico basin.

The Upper Cretaceous Eagle Ford shale extends directly into northern Mexico from South Texas, though it undergoes significant structural and lithologic changes just inside the border. The less renowned Upper Jurassic Pimienta formation, a prolific Gulf Coast source rock correlating with the Cotton Valley-Bossier-Haynesville sequence of East Texas, is regionally more extensive and uniform and could be a superior target to the Eagle Ford shale.

Regional geologic mapping reveals the Pimienta trend stretching 1,000 km across northeast Mexico (Fig. 1). The regional structure is simple throughout much of this trend, with few faults and mostly gentle dip angles (Fig. 2).[2] Shale thickness, depth, and thermal maturity are prospective within a belt 50-200 km wide and spanning 27,000 sq miles (17 million acres), covering just the Pimienta shale's two key basins: Burgos and Tampico-Misantla.

Total organic compound (TOC), mineralogy, porosity, and reservoir pressure appear mostly favorable, however, understanding is constrained due to fewer data. Further potential exists in the Sabinas, Veracruz, and Macuspana basins, though these tend to be structurally more complex. One geologic feature that differs from most US shale basins is the significant igneous activity (Miocene to Recent, both intrusive and extrusive) which may sterilize local areas.

As noted, many of the early Pemex shale wells tested at low rates, despite in some cases being directly adjacent to successful Eagle Ford producers in South Texas. This sug-

NORTHEAST MEXICO SHALE POTENTIAL

FIG. 1

Source: Advanced Resources International Inc., 2015

MEXICO'S ESTIMATED RESOURCE, BLOCKS

Basin	Number of blocks	Area, sq km	Resources, billion boe	Pemex shale wells
Burgos	124	14,406	6.5	27
Tampico-Misantla	158	18,528	17.6	3
Total	**282**	**32,934**	**24.1**	**30**

gests operational issues, such as poor lateral placement or ineffective stimulation, rather than inferior geologic conditions.

Pemex has since improved shale performance, testing 500 bo/d (37° API) from a horizontal Pimienta well in the volatile oil window.[3] Another Pimienta well, this one in the dry gas window, tested 10.9 MMcfd. Considering only 30 shale wells have been drilled thus far in Mexico, all Pemex operated, these results indicate that improved drilling and completion practices coupled with better sweet-spot well placement could lead to commercially viable production.

Ample resources

Pemex's latest official shale-resource estimate is 60.2 billion boe, comprising 31.9 billion bbl oil, 36.8 tcf wet gas, and 104.1 tcf dry natural gas.[4] The methodology and assumptions used for this estimate were not disclosed by Pemex. Separately, Advanced Resource International Inc.'s (ARI) 2013 assessment for the US Energy Information Agency (EIA), which included areas not assessed by Pemex, found 104 billion boe of risked, technically recoverable resources, comprising 13.1 billion bbl of oil and 545 tcf of natural gas.[5]

Our current analysis, based on a larger public data set that we assembled for our multiclient study, indicates the oil potential could be greater. Shale areas in the Burgos and Tampico-Misantla basins are structurally simple with few faults. Owing to gentle or flat structural dips, the liquids-rich windows often are wider than in the Texas Eagle Ford. Overpressuring occurs locally in these prolific and still actively generating source-rock shales.

Bid rounds

Seeking to reverse its declining oil output, Mexico is transforming its petroleum industry, with shale leasing as one of the pillars of reform. CNH and Sener recently published a detailed multiyear plan to auction shale blocks in the Burgos and Tampico-Misantla basins in four separate bid rounds.[6] Round 1 will focus on the Tampico, while Round 2 will feature extensive areas in the southern Burgos. Both regions offer liquids-rich shale targets, with the subsequent Rounds 3 and 4 allowing room for growth.

CNH has identified an estimated 24.1 billion boe potential in 282 blocks totaling nearly 33,000 sq km in the Burgos, Burro-Picachos, Tampico-Misantla, and other onshore basins (see accompanying table). Our independent analysis shows the offered blocks varying widely in reservoir quality and surface conditions, from excellent to poor. The better blocks have thick organic-rich shale of mainly carbon-

ate-silica lithology at optimal depth (~3,000 m) and thermal maturity (Ro ~1.1%), with few faults and flat surface topography. Other blocks have shale targets that, in our view, are too shallow (<1,000 m) or thermally not sufficiently mature to be prospective (Ro <0.5%). Access to infrastructure and services also affects block desirability.

Service access, security risks

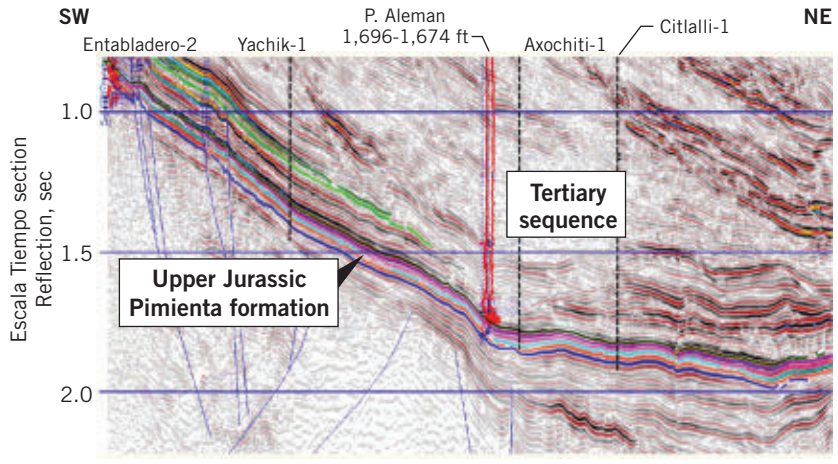
Once shale blocks have been awarded, service companies based in the southern US (Eagle Ford, Permian, and Haynesville) are positioned to bring in specialized drilling and completion equipment and expertise. The Mexican government is working to facilitate such cross-border trade. Local established service companies experienced with conventional oil and gas development in the Burgos and Tampico-Misantla basins offer partnering options.

Early Pemex shale wells reportedly cost $20-25 million each, triple the cost of equivalent Eagle Ford wells in South Texas. These wells were dispersed across the shale trend and required additional engineering. But capital costs should fall with greater geologic subsurface control, increased competition amongst service providers, and the inevitable logistical economies of scale. An influx of shale-savvy oil companies from abroad also will introduce needed efficiencies.

Potential complications, however, remain a part of the nascent Mexican shale industry. One of the largest is the local security situation. Both the Burgos and Tampico-Misantla basins are plagued by organized criminal gang activity. Shale development involving thousands of widely spaced wells and surface infrastructure presents daunting security issues. The government will need to focus law enforcement and security resources in these areas to enable large-scale shale development. Other countries (e.g., Colombia) have successfully grappled with similar concerns, but the security situation remains an active risk in Mexico.

PIMIENTA SHALE'S STRUCTURAL SETTING

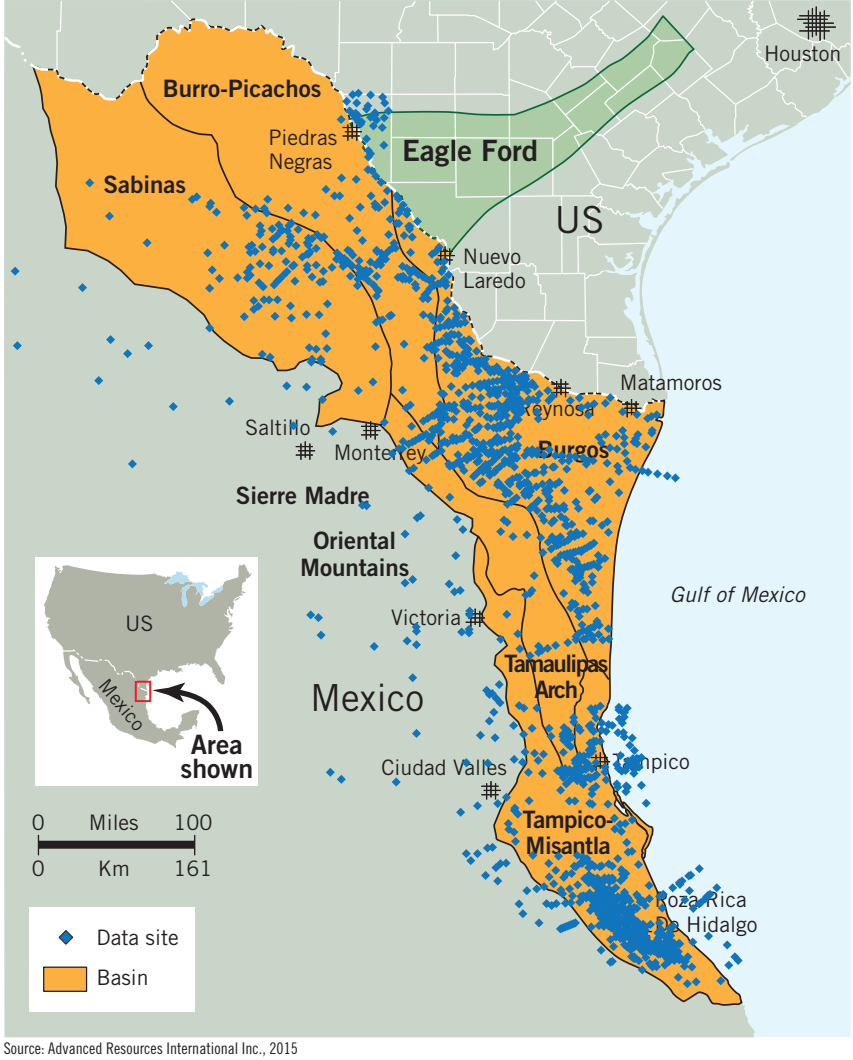
FIG. 2



Source: Pemex, 2012

NORTHEAST MEXICO SHALE, DATA EVALUATION

FIG. 3



Source: Advanced Resources International Inc., 2015

Future prospective

With the contract structure for shale licenses still somewhat uncertain, there is talk that the government may consider sweeter terms due to low oil prices. This seems likely following the poor response to the recent shallow offshore bidding round, only two out of 14 blocks being successfully awarded.

Mexico's switch from its old service agreements to more standard production-sharing contracts, providing the contractor with actual title to the resource, is a positive development. The government's share is determined by a royalty on gross revenues, an exploration fee, and a negotiated percentage of operating profit after cost-recovery. Signature bonuses are not required.[7]

Data availability for assessing Mexico's shale resource potential could be problematic. Much of the basic geologic and well data publicly available in other countries is kept confidential in Mexico. And the future CNH data room may provide limited-to-no data outside the offered blocks, hampering regional geologic interpretation and leasing strategies.

Fortunately, a wealth of geologic data on source-rock shales has been published in various Mexican technical journals and university theses. ARI has spent several years synthesizing data from these public sources into a proprietary GIS data base of Mexico's shale geology. Data were compiled from nearly 500 Spanish-language technical articles, mostly published before shale development began and focused on conventional source rock geology.

Shale data locations plotted on our Mexico maps provide an indication of geologic control (Fig. 2). With about 10,000 mapped shale geologic and reservoir data points, we now have reasonably good control of thickness, depth, structure, lithology, and thermal maturity for the principal Upper Cretaceous and Upper Jurassic shale targets across northeast Mexico. Geochemical data such as TOC and hydrocarbon indicators (HI) also were found but were less abundant.

High-graded Pimienta shale areas, for example, may have more than 200 m of gross shale thickness, double the typical Eagle Ford thickness in South Texas. Mineralogy comprises mainly calcite with minor quartz and illite clay. TOC generally is lower than in the Eagle Ford at 2-3% (unadjusted).

The Pimienta can be found in the volatile oil to wet gas windows (0.8-1.2%) and at optimal depths of 2-3.5 km. Porosity has been measured at a reasonably high 7%. Reservoir pressure often is high, reaching 50% over hydrostatic in places. The stress gradient has tested at a moderate 0.9 psi/ft, enabling good 3D fracturing systems during stimulation. Coupled with the vast prospective area, these are intriguing reservoir properties. OGJ

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OFFICE NATIONAL DES HYDROCARBURES ET DES MINES

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L'OFFICE NATIONAL DES HYDROCARBURES ET DES MINES « ONHYM » is issuing a tender in order to select companies for the development of gas resources of the prospective Gharb Center Area located onshore (part of the Gharb basin which has produced gas for decades)

The partnership with the selected company will be formalized through a petroleum agreement giving the right to an exploration permit

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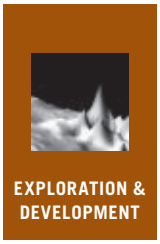
Fax 212 (0) 5 37 28 16 34

The terms of reference (CPS) can be downloaded from ONHYM web site (Link: http://www.onhym.com/en/calls-for-tender.html)

The deadline for bid reception is **19 August 2016, at 4 PM.**



EU unconventional resource development stalls

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European governments are reluctant to promote shale gas development even though technology has advanced and extraction processes have matured in North America. Europe continues to rely on Russia for much of its natural gas despite unconventional resources that could be exploited. Even considering the benefits shale development has brought to the US and Canada, Europe will likely not develop its unconventional resources in the near future.

This article outlines the many barriers European countries face in exploiting their shale resources and analyzes data from 2014 supporting the benefits shale gas development could bring to many European countries.

Crucial barriers

Technological and geological uncertainty, strong social opposition, and the lack of supportive governmental frameworks combine to provide the most detrimental barriers to rapid shale development across Europe. Exploration drilling is the best method of alleviating uncertainties about reserves estimates and reservoir engineering practices. With no real path to test prospective shale plays in Europe, it will be difficult to perform a rigorous economic evaluation of the region's unconventional basins.

In most European countries, social opposition further inhibits implementation of supportive regulations. The lack of exploration activity has kept recoverable reserves estimates low and high reserves estimates are typically required to display the true economic benefits of developing unconventional reserves. Near-term shale gas development is unlikely for countries caught in this type of gridlock.

US example

Commercial shale gas development depends on factors specific to each unconventional reservoir.[1] Production costs, resource volumes, and market prices factor into a play's viability. Other factors include drilling and completion cost, infrastructure availability, water access, and estimated ultimate recovery.

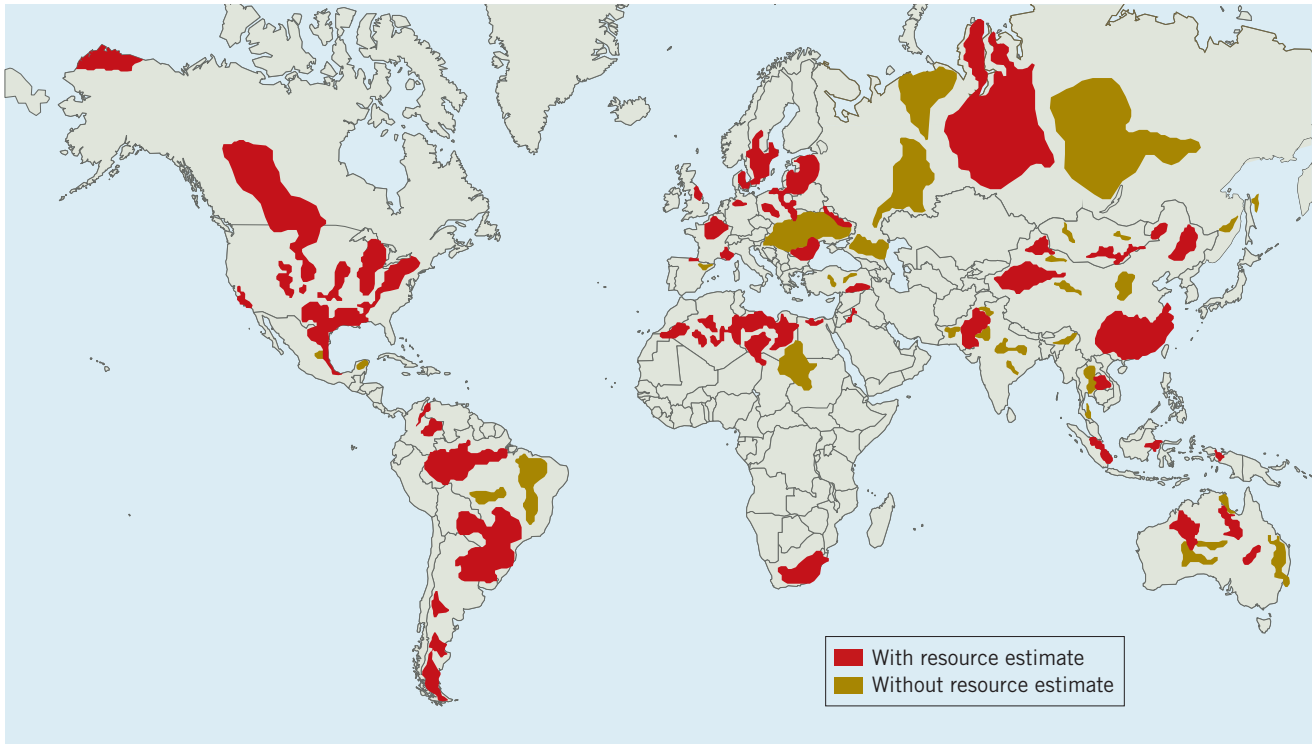
In the US, annual gas production increased 45% between 2008 and 2012, with unconventional gas accounting for 60% of this growth.[2,3]

As a result of increased production, US Henry Hub gas prices dropped to $2.76/Mbtu in 2012 from $8.85/Mbtu in 2008.[3]

The surge in shale gas production lowered LNG imports 50% and 45% in 2012 and 2013, respectively. Several regasification terminal projects were modified to become export plants and consumers began switching from coal to

ASSESSED SHALE BASINS

FIG. 1



Source: EIA, 2014

natural gas.[4] By 2012, coal-fired electricity generation had decreased to 42% of the US total from 48% in 2008.

The rise in shale gas production increased US energy security, reduced natural gas imports, and opened the possibility of exporting natural gas. The US was expected to become a net exporter of natural gas by 2018. But this outcome has become unclear in the current downturn.

Other countries evaluating their shale gas potential include Canada, Australia, the UK, China, and Argentina.

The countries of continental Europe have generally adopted a more cautious approach to unconventional development, although the region contains 615 tcf of technically recoverable shale resources (Fig. 1).[2]

Political, economic, social-environmental, and technological-geological concerns all play roles in the opposition to shale gas development, as do regulatory and market concerns.

Political factors

Environmental or "green" parties often have more influence in Europe than their counterparts in the US, and popular opposition to hydraulic fracturing keeps mainstream development at bay. In regions already affected by austerity policies, electoral support for ruling governments is low. Opening shale gas development in these countries could further weaken public sentiment.

Some Eastern European states are also reluctant to damage political and economic relationships with Russia as their primary natural gas supplier.

Economic factors

Recession, public debt, and the financial capacity of national oil companies and market investors have all impacted countries' interest in shale development on both macro- and microeconomic levels.

The European economy continues to languish in general. Individual companies have also had difficulty securing capital for the intensive exploration drilling and completions required in Europe, where current costs can exceed $15 million/well.[5,6]

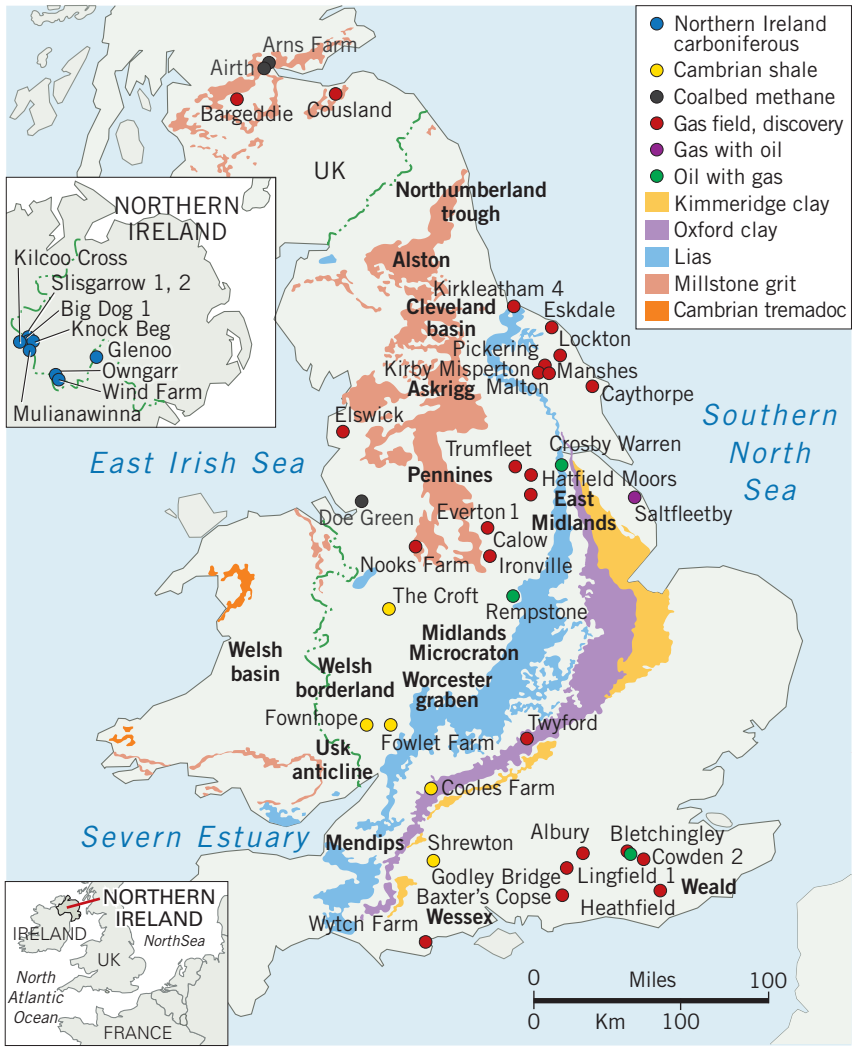
Social, environmental factors

Many Europeans have concerns related to the potential direct and indirect environmental impacts of hydraulic fracturing. Europe is more densely populated than the US, where most shale development has occurred in rural areas, and a public mistrust exists regarding government's ability to regulate the oil and gas sector.

Concerns about groundwater contamination, disposal of flowback water, and the volume of water used in drilling and hydraulic fracturing tend to raise fears regarding shale development.

UK SHALE FORMATIONS, WELLS

FIG. 2



Source: British Geological Survey, 2013

Other environmental concerns include:

- Seismic events.
- Potential fugitive methane emissions.
- Sand consumption in fracking fluids and concerns about silica pollution.
- Land surface disturbances that can impact biodiversity.
- Noise and visual impacts.

Technology, geology

Europe's basins differ geologically from the US in both formation and composition. In many cases, European unconventional reservoirs are deeper and harder to extract resources from, potentially requiring more expensive methods such as ceramic proppants.

Reserve levels also remain uncertain with so few test wells drilled in Europe, and the limited fracturing experience increases financial risk.

While pipeline infrastructure exists through most of Europe, some prospective areas lack the access needed to allow for commercial extraction.

Regulation, competition

Many European countries need to modify existing oil and gas legislation to clearly define the rights, duties, and liabilities related to shale gas exploration, including laws penalizing returns on shale investments.

Moratoriums and bans on hydraulic fracturing in some countries would have to be lifted. The absence of EU-wide regulation of shale-gas extraction and hydraulic fracturing produces uncertainty and results in an extensive bureaucracy that lacks definitive fiscal incentives to drive shale gas development.

Volatile natural gas pricing mechanisms in Europe further complicate the commercial viability of shale gas production. The lack of a well-developed onshore oil and gas service industry also makes Europe less competitive. Equipment and contract services are more expensive, and operations are carried out with less general experience.

Brent crude's fall below $40/bbl in December 2015, raised further doubt about European shale's commercial potential. The combination of cheap substitutes, such as coal, and low output from some of the European wells drilled to date has only deepened this uncertainty.

EU shale potential

Although a common EU legal framework is generally demanded by both supporters and opponents of shale gas development, it does not yet exist.

UK Prime Minister David Cameron considered the EU process too slow and felt it generated regulatory uncertainty that would reduce private investment in shale gas development. Cameron's position led to rejection of amendments to Directive 2011/92/EU, which proposed requiring an environmental impact assessment for all upstream activities involving hydraulic fracturing.[7] Instead, the European Commission developed a recommendation on how to regulate hydraulic fracturing activities to ensure the public health, environmental protection, efficient use of resources, and public access

to information.[8] The recommendation included:

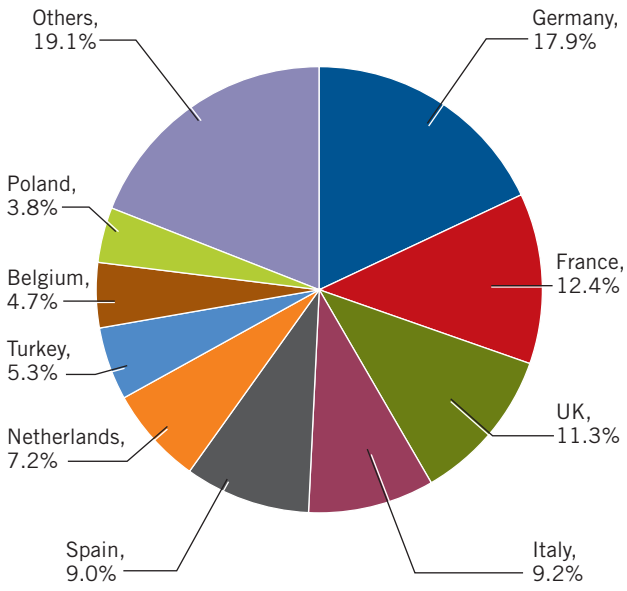
- Performing strategic environmental assessments prior to granting licenses.
- Risk assessments.
- A minimal distance between fractured zones and groundwater.
- Fracturing fluids disposal management.

These recommendations, however, are not legally binding and EU member states can decide whether or not to follow them.

Spain exemplifies strong social opposition to unconventional development despite its dependence on imported oil and gas. In 2014, 300 municipalities declared themselves "fracing free." Four of the country's 17 regional governments banned hydraulic fracturing in portions of Spain's most prospective areas.

France imports 97% of its hydrocarbons.[9] Natural gas represented 15% of its primary energy mix in 2012. Despite being one of the smallest gas consumers in the EU, France has a fully functioning, interconnected gas market. It has prospective basins and could provide a competitive environment for unconventional development,

EUROPE'S 2014 PETROLEUM CONSUMPTION FIG. 3



Source: EIA, 2014

but enacted a total ban on hydraulic fracturing in 2011 (OGJ Online, May 12, 2011). The government's moratorium is strengthened by broad social opposition to the technology.

Poland has made attempts to reduce its carbon intensity and diversify its energy mix with shale gas, but suffers from technological-geological barriers. The government's regulatory framework has been weighted down with excessive bureaucracy increasing the time required to secure drilling permits, amend existing permits, or reach an environmental decision on subsequent drilling..

The UK has promise as a shale gas producer (Fig. 2). Despite the growing dependence on hydrocarbon imports, the country is one of the largest EU oil producers. The country added 907,000 b/d of natural gas liquids in 2014, but its overall hydrocarbon production is declining. As the third-largest EU consumer of hydrocarbon resources (Fig. 3), the UK is implementing policies to develop shale gas and reverse a potentially precipitous decline. Given the barriers to continental European shale development, the UK is the most likely EU member to develop its unconventional resources..

Short-term potential

The outlook for European unconventional resource development is bleak. Advances in shale extraction projects in France seem highly unlikely. Both the regulatory ban on fracing and strong social and political opposition to the practice appear to be entrenched. The country's strong nuclear energy mix combined with well-diversified fossil fuel import sources also suggest a continued lack of support for shale gas development.

Low reserve estimates for shale gas and sustained social opposition to its development create a similarly bleak scenario for unconventional development in Spain. The Spanish government has not enacted fiscal incentives promoting development.

Poland was the first European country to pursue shale-gas exploration, but its prospects have worsened in the absence of needed regulatory changes. Increased time cycles, unclear directives, and an indecisive environmental evaluation system have also discouraged companies from investing in Poland's shale prospects.

The UK is working to implement regulations for domestic shale gas exploration. While the path is not yet clear, it appears the country will develop its unconventional resources once the needed regulations have been passed.

The current price climate mitigates against EU shale gas production becoming a reality. The UK could play a pivotal role in reversing this fortune if its attempts are successful. If UK efforts fail, however, resolve could strengthen against unconventional resource development elsewhere in Europe.

Acknowledgment

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Bearing innovations extend roller-cone bit life

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A new tapered bearing assembly, developed specifically for roller-cone rock bits, significantly increased bit life for a Middle Eastern operator. This technology can help oil and gas customers avert premature bit failures, minimizing nonproductive time, and decreasing costs. Longer-life expectancy of the tapered bearing and seals package improves the attractiveness of roller-cone bits in applications where fixed-cutter polycrystalline diamond compact (PDC) bits traditionally have been selected.

Engineers used analytical modeling and simulations to build 28-in. tungsten carbide insert (TCI) bits, which were tested in a laboratory and then sent for a Middle Eastern exploration run in which the bearing assembly's first iteration increased reliability and endurance.

The run had 70% more bit revolutions and 58% more footage than the field average. Bit life traditionally constrains roller-cone technology. Traditional journal bearings and cylindrical-roller bearings with ball-lock cone retention have inherent play, reducing bearing and seal life.

Shorter bit life increases drilling costs by requiring more trips and more drill bits. Recent innovations effectively packaged application-specific, tapered-bearing technology into roller-cone assemblies (Fig. 1).

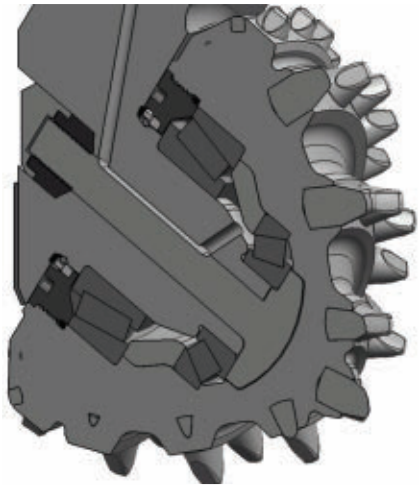
A preloaded bearing package eliminated axial and radial play, which also stabilized the sealing interface between the head and cone, promoting extended seal life. Analytical modeling helped designers define and simulate various loading conditions downhole, including reaming, up-drill, directional drilling, and high-weight.

Proprietary bearing-analysis software enabled development of bearings that perform effectively across various loading conditions. Roller-cone rock bit bearings originally were designed for vertical shallow wells, which differ greatly from today's very deep wells and horizontal wells.

Opposed-taper roller bearings eliminate play and stabilize cones, but need to be configured into roller-cone design. Many roller cones use inserts in drilled holes having sufficient depth to retain them.

Shell thickness between a hole's bottom and the internal bearing assembly must be kept above a minimum to ensure sufficient strength to withstand downhole drilling conditions. The cone assembly also must be attached to the leg with enough strength to endure downhole drilling.

Attachment occurs via blind-hole assembly. The bearing assembly must be precisely preloaded to allow for optimum bearing life and seal performance. Lab tests validated the opposed-tapered roller bearings (TRB) as did successful field trials.



A tapered bearing assembly increased bit life for an operator in the Middle East working with Baker Hughes Inc. (Fig. 1).

Based on a presentation to SPE/IADC Drilling Conference and Exhibition, London, Mar. 17–19, 2015 .

Roller-cone bits still play a role in drilling, but bearing technology has not kept pace with the hybrid technology that has merged PDC bits and roller-cone bits. TRB application increased both capacity and life of rolling-cone bits.

Tapered roller bearings

Anti-friction bearings can meet numerous needs. Various anti-friction bearing types exist, requiring compromises during bit design and selection decisions.

Roller-bearing or ball-bearing types can satisfy boundary (or fixed) conditions in widely varying applications.

Customized bearings improve performance in specific operating conditions. The bearing raceway and roller profiles can be designed to control maximum stress levels, boosting durability and enhancing performance in demanding applications. Optimization normally targets bearing profile, surface finish, material, coating, and precision setting.

Key boundary conditions to be considered include:

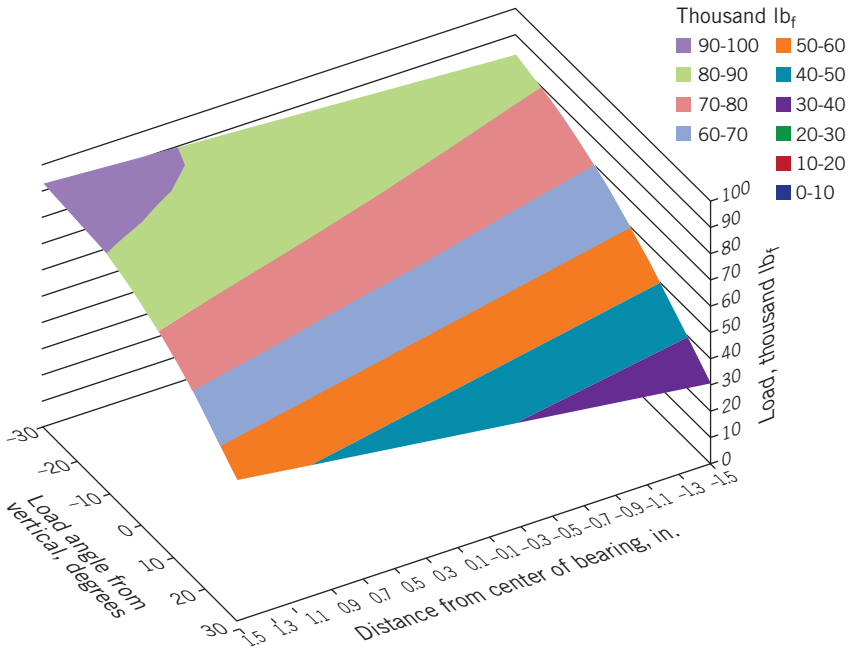
- External loads; e.g., radial, thrust, moment, shock, and combination loads.
- Operating temperature range, such as extreme limits and thermal cycling.
- Fluids, debris, and vibration.
- Spatial constraints.
- Seal type and performance.

Early cylindrical-roller bearings (CRB) featured two roller-guide flanges on the outer raceway and none on the inner raceway. Most current CRB deploy crowned rollers to avoid premature spalling from roller-edge loading. Crowning addresses loading concentration from inner-race misalignment caused by combined bearing and system deflections.

In rock bits, the assembly attaches via a central beam between the cone assembly and leg section. The beam attaches to the leg (or static side of the bit assembly), providing a structure to the bearing and supporting bend loading.

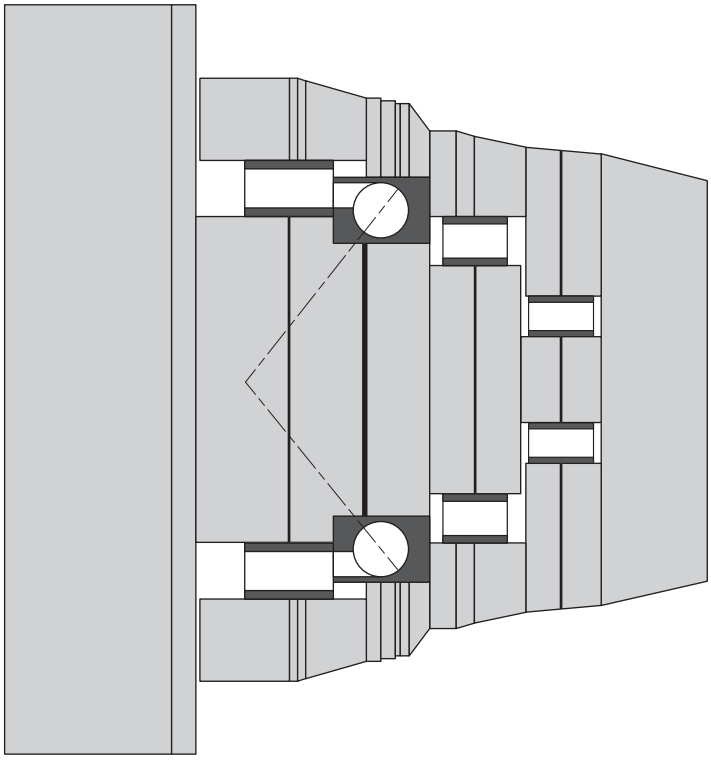
MAIN-BEARING DYNAMIC EQUIVALENT RADIAL LOAD

FIG. 2



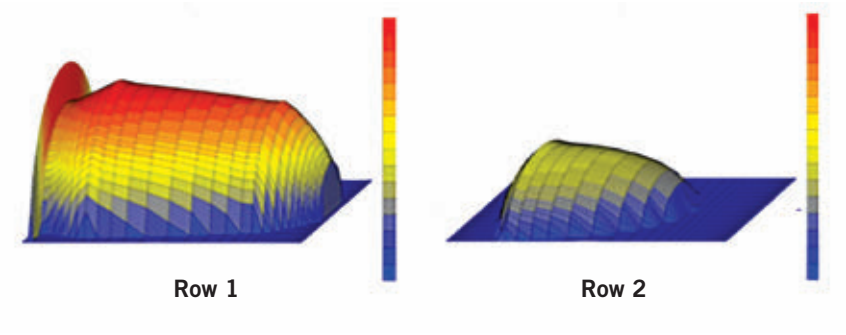
BASIC BALL, CYLINDRICAL ROLLER BEARING CONFIGURATION

FIG. 3



CYLINDRICAL ROLLER-BEARING, PRESSURE DISTRIBUTION PLOTS

FIG. 4



This TCI bit was brought to the surface after 216-hr run because of a suspected washout in the drilling string. The bit was dull-graded (Fig. 5).

The leg's bearing section needs to be made of low-carbon materials that can be welded. Since the beam is independent of the head, high-strength alloys establish a strong overall leg-section bearing pin.

Bearing lubrication also must be addressed. While the central beam is keyed to the leg section to prevent rotation, targeted grease channels can be integrated to the beam's shaft in a non-loaded direction. From precise flats on either side of the shaft of the central beam, lubricant flows through holes feeding the opposed tapered bearings. This assembly diverts the lubrication channels away from the bearing axis' center, typically the assembly's highest-stressed area.

The cone-bearing assembly uses one axial contact point and precise shimming controls tolerances. A preload setting of the opposed tapered-bearing configuration increases system stiffness and reduces deflection.

A permanent shim, under the head of the central beam, establishes preload settings in the bearing assembly. Axial loads stem from two sources:

- Taper in the bearings that split any loading into axial and radial load components.
- Inward loading on the cone assembly, particularly prevalent during directional drilling or reaming.

Applying calculated torque settings beyond severe-loading conditions to a nut on the end of the central beam prevents elongation of the beam during operation.

The overall size and cutting structure of the drill bit is as important as the bearing assembly. The varying size of the cones and the natural taper of the cutting structure decrease the radial space available toward the end of the cones.

The package needs adequate clearance for cutting-structure elements while maintaining load capacity. Simulations showed that available space played a primary role in developing a nominal effective bearing spread through taper angles and bearing profiles.

In blind-hole application of bearings, a threaded ring is used to retain the bearing assembly in the cones. The ring threads down until it contacts the outer race of the main bearing, fixing its position. The bearing assembly is installed with no gaps in the system, to prevent movement. The threaded ring seals the cone assembly to the leg section.

A static o-ring seals the ring and the cone together. A dynamic seal between the ring and the leg enables a smaller-diameter seal, linearly reducing the seal-sliding speed which reduces overall wear and extends seal life. Lower speeds reduce seal-face temperatures and slow degradation.

Analysis, simulation

Bearing fundamentals, tribology, and advanced modeling are a few aspects of total system analysis when maximizing bearing-fatigue life (or service life) under high-loading, high misalignment, thin lubrication film, debris, or other prevalent drilling conditions. Bearing evaluation involves a detailed review of boundary conditions and performance expectations.

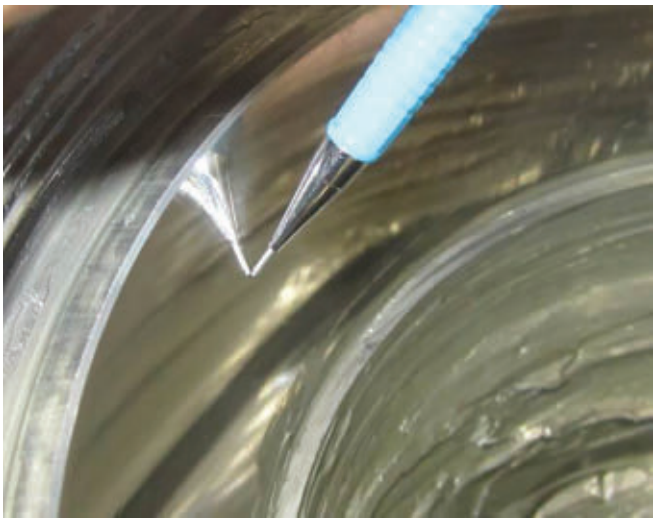
Designers determined bearing loads by evaluating bit loading from various new-well profiles and historical drilling data (Fig.2).

Varying cutter profile designs, bit designs, and applied weights on bit prompted bit-by-bit development of the expected duty cycle. Consideration also was taken for boundary conditions.

Although current roller-cone bits use CRB and ball arrangements, preloaded tapered-roller arrangements increase bit performance. A preloaded tapered-roller bearing offers clearance advantages over other bearing types, especially when the bearing encounters system misalignment.

Improving load distribution between the two bearing positions increased power density. Heavy loading with repeated stops and starts of the roller-cone bits creates misalignment. Traditional CRB and ball lock roller-cone design and the new tapered bearing series were evaluated in larger bit sizes (Fig. 3)

Optimizing roller-cone geometry allows handling of the most severe-loading conditions, which result in off-set load-



A 216-hr run left the raceways (left) and the roller elements of the bearings within the customer's requirements. (Fig. 6).

ing and uneven load distribution on the bearings. The roller-cone load location and load angle induce an over-turning moment force on the bearings. Such load scenarios often reduce seal performance and bearing reliability. Heavy loading with repeated stops and starts of the roller-cone bits creates misalignment of the roller-cone and bearing axis.

A proprietary bearing-analysis program accounted for multiple loading conditions, misalignment, lubrication effects, and determined fully adjusted bearing-performance results. Simulations considered nominal load directions, heavy outward loads, and severe inward loads from reaming or directional drilling. Analysis prompted changes that increased calculated bearing-fatigue life and improved potential seal performance.

A tapered-roller bearing has as much as six times more radial stiffness as a comparably sized angular contact ball bearing and twice as much radial stiffness as a comparably sized cylindrical-roller bearing for a zero-clearance condition. Increased stiffness allows for only two tapered-roller bearings and increases seal-face stability, leading to a more evenly distributed load and extended seal life.

Estimated loads and physical space limitations allow optimizing of bearing geometric-spread. The inherent taper moves an effective bearing center-location from on center, for indirect mount like a CRB, to further outside. The angularity of the bearing, or "K factor," is a function of the half-included cup angle and is the ratio of basic dynamic radial-load rating (C90) to basic dynamic axial-load rating (Ca90) in a single row-bearing.

Too much cup angle can result in reduced radial load capacity. Selection of a nominal tapered-roller bearing cup angle improved tilting stiffness or resistance to overturning loads, helping stabilize the cone assembly during drilling.

Bearing preload minimized axial movement of the roller cone under operating load. Axial preload values were reviewed to maintain a minimum load zone in the setup-bearing row. Bit designers refined the setting and balance life, contact stress and distribution, heat generation, and other bearing performance indicators.

Excessive axial preload can lead to unwanted heat generation, lubrication problems, premature bearing damage, and reduced bearing-fatigue life. Excessive axial play results in fewer rolling elements carrying the load, increasing individual roller load and reducing bearing life. Optimizing the bearing setting improves bearing life and load sharing between bearing rows.

The enhanced internal geometry enables reduction of geometric stress concentrations at the extreme edges of the roller-raceway contacts. Specific component profiles were designed for a uniform stress distribution under normal and severe loading conditions. Standard and inward loading conditions of traditional CRB configuration vs. TRB were studied with displacement amplitude reduced by 50 times. Plots showed loading distribution on standard ERB rollers (Fig. 4).

It is difficult to control load distribution across the CRB rows. Raceway and roller diameter tolerances result in a minimum mounted-radial internal clearance that is non-adjustable and required for assembly of the roller cone onto the leg. The peak load is shared in TRB arrangement, stresses are reduced, and load is more evenly shared by the system's rollers.

High overturning moment loads, deflection, or misalignment resulted in less than optimal roller-raceway contact stress distribution using a standard bearing geometry. An ideal pressure distribution involves an optimized roller profile with loading relatively centered between the two bearing positions.

When studying contact stresses at the most loaded roller during off-set loading, high overturning loads, or misaligned conditions, non-optimized profiles resulted in uneven pressure across the roller-raceway contact. Geometric modifications improved the center and edge stress values along with the pressure slope across the roller length.

Testing the first bit assembly with the tapered-roller bearing configuration in a lab under controlled conditions yielded initial proof of concept. Water was used and the test conducted only under atmospheric pressures, which don't impact bearing capability. The bit was a 28-in. TCI-roller cone that drilled into two different limestones. It was run twice for just more than 36-in. of effective drilling per run. Rotating speed was brought to 120 rpm and held at 90,000 lb_f weight on bit (WOB). Cone-rotating torque was smooth and cones spun freely with no difference in rotating torque. This bit was sent for field testing.

Field testing

The bearing was tested in a Middle Eastern application. The bearing package along with a metal face-seal system was installed on the 28-in. tungsten carbide insert bit IADC 445, as classified by the International Association of Drilling Contractors.

Section length was typically 2,500-3,500 ft, and IADC 435 or 445 roller cones on performance motors delivered optimum results. Bearing and seal life constitute a limiting factor that resulted in more runs on rotary bottomhole assembly and multiple trips. Roller-cone bits were pulled out of hole at a maximum of 1.3 million revolutions (MRevs) and an average of 0.91 Mrevs. The tapered-bearing bit extended the maximum to more than 1.7 MRevs.

The subject bit was run with a performance motor assembly (12¾-in. OD, 5/6 lobe, 0.13 rev/gal) that drilled through a section of 10,000-20,000 psi unconfined compression-strength rock consisting of anhydrites, limestone, and dolomitic limestone with minor shale layers.

Limiting penetration rate to 30 ft/hr prevented circulation loss. Compared with average parameters in offset runs, the bearing and seals experienced the same WOB while rpm was 100% higher. Results showed 31% higher revolutions compared with previous best performance.

In another test run in the Middle East, the same bit design with a rotary assembly drilled comparable lithologies within 10,000-20,000 psi unconfined compressive strength. Crews drilled 3,555 ft, reporting the bit accumulated 216 hr and 1.6 MRevs with 60,000-80,000 lb-ft WOB and speeds of 70-100 rpm. The run included backreaming twice per stand. The bit came to the surface because of a suspected drill-string washout and the dull grading satisfied customer requirements (Figs. 5-6).

Any type of reaming typically causes premature bearing and seal failures, but this was not the case for the tapered bearing assembly. The bearing assembly maintained preload with a visually polished surface on raceways and rollers. Inward loading caused more nose-bearing wear than main-bearing wear.

The cone profile traces on the main bearing showed very good conformity and very little wear across the raceway surface. No spalling resulted and bearing integrity remained uncompromised.

The use of tapered-roller bearings reduces and potentially eliminates axial play and angular misalignment while providing superior reliability, including but not limited to high-speed motor bottomhole assembly (>350 rpm and up to 500 rpm).

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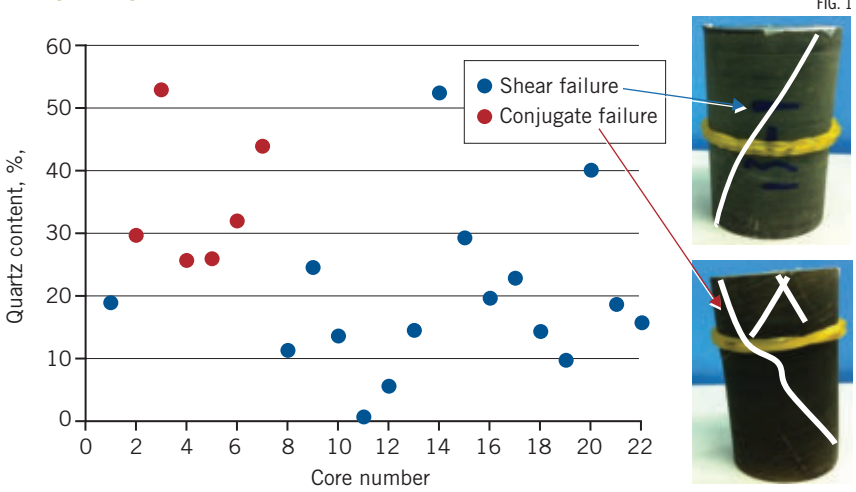
DRILLING & PRODUCTION

Hybrid fracturing pilot increases China's Dagang tight oil production

FAILURE MODEL

FIG. 1



TIGHT OIL FIELD COMPARISON

Table 1

Items		Bagang	Bakken	Eagle Ford
Source	Depth, m	2,900-4,600	2,500-3,300	1,200-3,600
	Thickness, m	75-150	2-18	20-60
	TOC, %	2-6	10-14	3-7
	Ro, %	0.5-1.0	0.6-1.0	0.5-2.0
	Kerogen type	I + II	I + II	I + II
Reservoir	Lithology	Siltstone, fine sandstone	Dolomitic, argillaceous siltstone	Marlstone
	Thickness, m	7-40 m	5-30 m	30-90 m
	Porosity, %	5-12	2-12%	2-12
	Permeability, md	Mainly 0.001-1.0	0.01-1.0	<0.01-1.0
Viscosity of crude oil, MPa•s		6.3-34.8	0.36	—
Density of crude oil, g/cu cm		0.87-0.90	0.81-0.83	0.82-0.87
Pressure coefficient		0.94-1.19	1.35-1.58	1.35-1.8

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Hybrid fracturing used in combination with secondary fracturing boosted stimulated reservoir volume (SRV) and conductivity in a pilot on Dagang-field vertical oil wells in China's Bohai basin.

The combination of fracturing techniques helped producers unlock tight oil reservoirs more effectively than a single fracturing technique would have. Hybrid fracturing yields a complex fracture network by using slick water or linear gels and carries proppant into the fracture using cross-linked gel.

Tight oil reservoirs, usually involving clastics or carbonates, exist in plays where oil migrated from the source rock to a reservoir offering very low matrix-permeability (in-situ permeability ≤0.1 md).[1] Similar to US plays, tight oil accounts for much of China's reserves. Table 1 compares the two nation's tight oil reservoirs.

Companies developing northeast-

ern China's Dagang field, discovered and brought on stream in 1965, strive to more effectively produce tight oil using emerging completion and production technology to handle the main reservoir's high water cut.

Researchers applied secondary hybrid fracturing to eight wells. Different from conventional fracturing, secondary fracturing has two independent procedures. The first procedure is like conventional fracturing but the well also is shut in for about 1 hr to ensure proppant settlement.

The second fracturing procedure helps obtain complexity and conductivity. Well G1, with a vertical depth of 3,483-96 m and reservoir thickness of 13 m, showed the best results. Logging data demonstrated average permeability of 0.29 md, average porosity of 8.56%, and oil saturation of 48.1%.

Well G1 has 79.1% broad-brittle minerals and 33% quartz. Rickman's brittleness index showed 51% medium brittleness. G1's horizontal-stress difference coefficient was 0.2-0.3, higher than differential strain analysis results from other wells.

Based on optimal length of 160 m and equivalent average permeability of 6 md, optimal proppant volume was 52.5 cu m.

This secondary-hybrid fracturing pilot increased fracture complexity by using mostly low-viscosity linear gels in the first stage and a cross-linked gel in the second stage.

Stress interference reduced the horizontal-stress difference coefficient during first-stage hydraulic fracturing. A lower stress-difference coefficient also can increase fracture density and connectivity.

The use of numerical simulation helped optimize field test parameters for fractures (Table 2).

EQUATIONS

$$B = \frac{1}{2}\left(\frac{E - E_{min}}{E_{max} - E_{min}} + \frac{v - v_{min}}{v_{max} - v_{min}}\right) \quad (1)$$

$$\delta = \frac{\sigma_H - \sigma_h}{\sigma_h} \quad (2)$$

$$V_f = \frac{128 L_f (\overline{K}_{PZ} - K_m A_m)(1 - v^2) P_{net} H_f \alpha \eta}{45 E F_c} \quad (3)$$

NOMENCLATURE

B = Rickman brittleness index, %
E_{max} = maximum static Young's modulus MPa
E_{min} = minimum static Young's modulus MPa
MPa, v_{max} and v = the maximum and minimum static Poisson's ratio
δ = the horizontal stress difference coefficient
σ_H = maximum horizontal principal stress
σ_h = minimum horizontal principal stress
V_f = equivalent fracture volume or proppant volume, cu m
L_f = equivalent fracture half-length or HPZ half-length
A = the area of HPZ, sq m
K_m^{HPZ} = matrix permeability, md
A_m = matrix cross sectional area, sq m
V = Poisson's ratio, dimensionless
E = Young's modulus
MPa, Fc = fracture conductivity, d·cm
P_{net} = net pressure, MPa
H_f = equivalent fracture height, m
α = unit conversion factor
η = correlation factor, dimensionless

DAGANG OIL WELL G1

Table 2

Stage	Liner gel, cu m	Cross-linked gel, cu m	Fluid volume, cu m	Rate, cu m/min	Proppant volume, cu m	Shut-in interval, min
1	207	191	398	8	21	50
2	117	291	408	8	31.5	50

Red lines drawn on cores show the distribution and width of natural fractures (Fig. 2).

Fracability

Tubing-head pressure of the second stage was about 15 MPa lower than the first stage, likely because the first stage generated a complex multi-branch fracture. The second stage experienced a different failure mode.

Well G1 had a complex fracture network and higher fracture conductivity. Its oil production rate increased to a rounded 213 b/d from 4 b/d after fracturing with a stimulation ratio of 47.4.

Researchers expanded testing of the secondary hybrid fracturing method to another seven vertical wells (Table 3). The wells in which conventional cross-linked gel fracturing was used in only one stage had average production of 35 b/d.

The field test involved the second member of Paleogene

PILOT WELL TEST, FRACTURING FORMULAS

Table 3

Well name	Method	Depth, m	Permeability, md	Porosity, percent	Thickness, m	Fluid volume cu m	Rate Minimum cu m/min	Proppant volume cu m	Oil production cu m/d	Stimulation ratio
K9	Conventional fracturing	3,794.4-3,796.3	0.240	7.80	8.1	206.5	5.00	17.20	5.20	144.6
K17-1		4,106.8-4,147.1	0.420	6.50	20.1	396.9	5.42	34.00	5.70	27.2
K17-2		3,968.8-3,971.5	0.710	9.40	18.3	406.6	5.00	28.00	5.90	17.6
G6	Secondary hybrid fracturing	4,135.5-4,164.8	0.770	7.90	29.3	924.2	5.60-5.90	71.80	32.60	165.7
G1		3,483.2-3,496.2	0.290	8.56	13.0	821.1	8.00	52.50	33.80	47.4
K26		4,061.1-4,073.8	0.287	8.13	7.0	850.9	3.70-5.50	50.30	23.60	9.8
G10		3,810.4-3,830.2	0.080	6.14	13.6	523.3	6.10	34.09	2.92	69.0
G3		4,011.9-4,053.7	0.684	10.30	14.7	821.0	6.10	51.50	30.10	144.2
G9-1		3,799.2-3,820.4	0.044	5.09	9.8	645.0	6.90	36.41	6.34	6.2
G9-2		3,689.9-3,711.8	0.255	8.05	21.9	522.6	5.65	45.20	1.01	474.0
G13		4,138.0-4,171.0	0.270	7.30	23.8	641.0	4.70-5.80	23.50	5.10	56.6
G108		3,196.0-3,236.0	0.550	8.51	27.5	538.0	8.00	45.00	4.44	361.0

Kongdian formation of Cangdong sag (Kong 2 member). Reservoir characteristics exhibited fine-grained facies sedimentation.[2]

The Kong 2 member shows four vertical sequences: Ek24, Ek23, Ek22, and Ek21 from bottom to top. Kong 2 features sedimentation created during maximum lake flooding in the Kongdian formation. Sedimentation consists of fine grey sandstone, grey mudstone, and red mudstone.

Tight oil comes from good shale having enough thickness, total organic carbon (TOC), and formation conductivity indicated by vitrinite reflectance, Ro, which demonstrates the thermal maturity of organic matter. But the low pore space, permeability, viscosity of crude oil, and pressure coefficient show the low-flow capacity of oil in reservoir rock.

Dagang field has higher oil viscosity and density than the Bakken formation in North Dakota or Eagle Ford shale in South Texas. Consequently, Dagang field, which has a deeper formation, requires more SRV than the Bakken or Eagle Ford plays.

Reservoir characteristics and engineering factors, including rock brittleness, stress difference, natural fracture, net pressure, and fracturing fluid viscosity, determine a formation's ability to generate a complex fracture network (fracability).

X-ray diffraction data show Kong 2 member has broad brittle minerals, including quartz, feldspar, and carbonate.

Kong 2's average Young's modulus was 18,047 MPa while the average Poisson's ratio was 0.322 during a triaxial compression test in which the confining pressure was 40 MPa. The average Rickman brittleness index was 42.3% using Equation 1 for the triaxial compression test.[3]

Both the mineral composition and mechanics parameters reflected the reservoir's medium brittleness. Triaxial compression test results involved two categories: shear failure and conjugate failure. Conjugate failure was more prone with increased quartz content (Fig.1).

Shear failure accounted for most failures while conjugate failure was limited. Results demonstrated the difficulty of generating complex fracture networks in the Kong 2 member given its mineral components.

The differential strain analysis shown in Table 4 yielded Kong 2's in situ stresses. The horizontal principal stress gradient is 1.41-1.71 MPa/100 m and the horizontal stress difference coefficient 0.1-0.2 (Equation 2).

Natural fracture widths, shown in core samples in Fig. 2, typically measured 0.03-0.23 mm.

The Kong 2 member demonstrated primarily horizontal bedding and middle-low angle natural fractures. Natural fracture conditions proved favorable for generating a fracture network, but maintaining conductivity under high vertical stress in those fractures proved difficult.

The brittleness index, the stress difference, and natural fracture were moderately favorable. The Kong 2 member provides medium fracability and development potential using an appropriate combination of fracturing techniques.

Conductivity

Researchers used massive hydraulic fracturing to connect natural fractures across a large area and increase SRV.

Two failure types resulted from this process: tensile fracture and shear fracture. High-concentration proppant was needed to achieve conductivity when the rock faces aligned in tensile fractures.

Resulting displacement yielded conductivity and also provided self-support within the shear fractures. Conductivity of proppant-supported aligned fractures was tested based on API standards. Smooth rock plates were made from cores of the Kong 2 member, as outlined by API standards.

A broken-gel fracturing fluid carried ceramic proppant. Researchers studied proppant embedding and fluid damage effects by injecting broken gel into the cell for 2 hr at 0.5 MPa before the test.

With increased size and proppant concentration, conductivity increases were obvious at closure pressures lower than 40 MPa. Conductivity only increased slightly when closure pressure was higher than 40 MPa. The fracture can achieve conductivity of about 5 darcies-cm (d·cm) under 50-MPa closure pressure.

Self-supported displaced fracture sensitivity was tested by following API conductivity standards. Testers used Kong 2 member plates and a rock splitter.

Cutting the opposite sides of the top- and bottom-fractured cores yielded displacement of 2.54 mm. Plates were mounted in a conductivity cell without proppant. Test fluid was water with 2% fracturing fluid. The self-support displaced fracture started with conductivity of 13.6 d·cm, which declined quickly to 0.01 d·cm at 34.5-MPa closure pressure.

Higher closure pressures produced conductivity values beyond the minimum test limit. The in situ stress of the Kong 2 member was more than 44.4 MPa, so conductivity of self-support displaced fractures was very low.

The fracturing design model for Kong 2 did not test for self-support displaced fractures. An appropriate proppant concentration designed for the specific fracture network enabled better crude oil flow.

Fracturing design

Fig. 3 shows the basic workflow of the fracturing design process for tight oil reservoirs. The fracture networks (or SRV) were simplified as a high-permeability zone (HPZ) according to the equivalent seepage principle.[4]

Calculating a ratio of the HPZ width and length yielded a fracture complexity index. Index calculation used fracability evaluations or microseimic data.

HPZ parameters included area and equivalent average permeability. Parameters were tested for optimized productivity simulation. Kong 2 member's optimal length was 160 m and equivalent average permeability was 6 md.

Equation 3 calculates the required proppant volume based on fracture conductivity and optimal HPZ parameters.

Conductivity of the self-support displaced fractures proved very low. Researchers selected proppant-support aligned fracturing as the primary approach to maintain fracture conductivity.

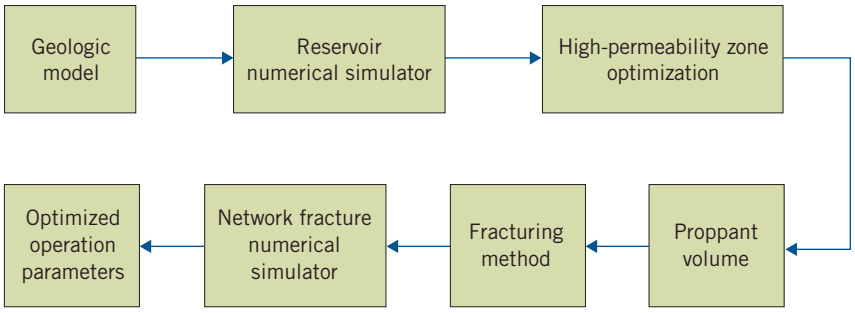
Based on the optimal HPZ parameters, fracability, and conductivity, a combination of secondary and hybrid fracturing was the best fracturing formula to boost tight oil production from the Kong 2 member.

Hybrid fracturing involves creating complex fractures using slick water or linear gels and then carrying proppant into the fractures with cross-linked gel.[5]

Typically, hybrid fracturing yields a more complex fracture network than cross-linked gel fracturing alone. Gel enhances proppant placement better than water. Researchers found hybrid fracturing was necessary to balance effective fracture length and equivalent average permeability (or conductivity) for the Kong 2 member.

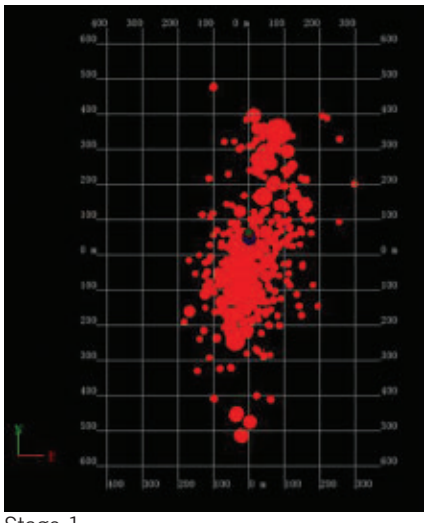
But for middle-fracability vertical wells, hybrid fracturing's complexity was still insufficient, prompting use of secondary hybrid fracturing. Secondary fracturing was di-

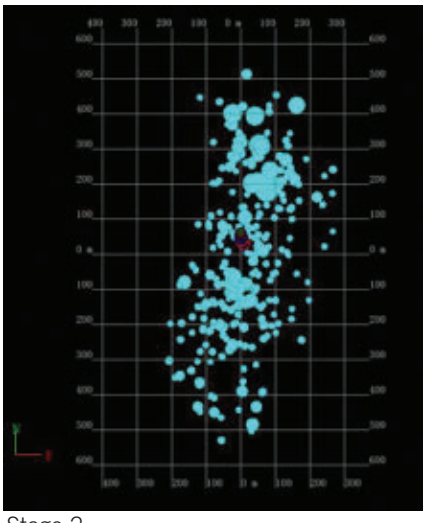
FRACTURE DESIGN PROCESS FIG. 3

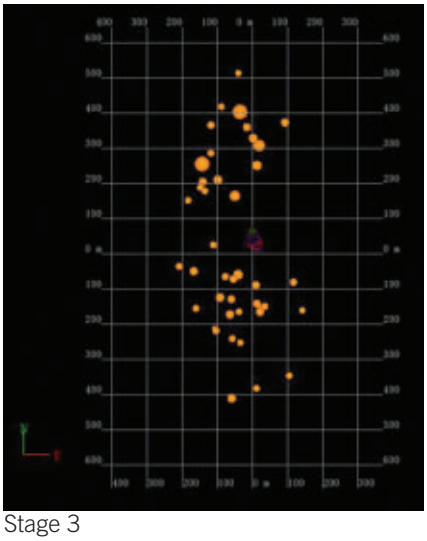


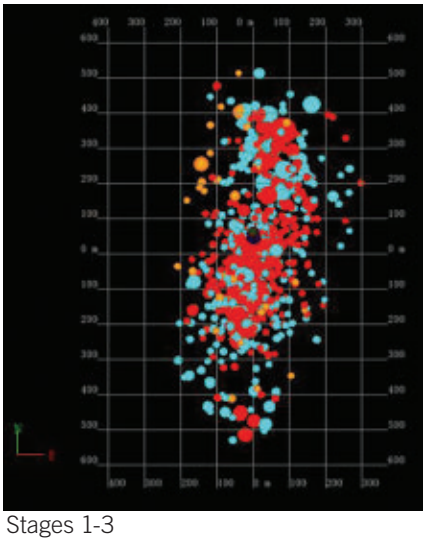
IN-SITU STRESSES Table 4

Well	Depth, m	Principal stress, MPa: Maximum horizontal principal stress	Minimum horizontal principal stress	Vertical principal stress	The horizontal stress difference coefficient
G-A	3,158.36	53.3	44.4	72.5	0.2
G-B	4,113.25	70.2	63.6	106.1	0.1


Stage 1


Stage 2


Stage 3


Stage 1-3

Microseismic images show the process of vertical well fracturing stages. Fig. 4

vided into two fracturing stages with a shut-in interval to obtain enough complexity and conductivity.

Fig. 4 shows seismic results at three stages of fracturing with two shut-in intervals in a vertical well on a tight-gas block. The main fracture network was generated mainly in Stage 1. The SRV (or HPZ) increased slowly, and density and connectivity improved, during Stage 2.

Secondary fracturing proved best for Stage 3, with secondary hybrid fracturing best for the Kong 2 member. Considering proppant volume and secondary hybrid fracturing, crews targeted optimal HPZ parameters using a fracture numerical simulator.

Dagang tight oil wells completed in a pilot using a combination of fracturing techniques had higher production rate increases, averaging 99 b/d, and the process boosted the stimulation ratio to 150.4 from 63.1.

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Price collapse slows midstream operators' 5-year growth streak

Dan Lippe
Petral Consulting Co.
Houston

Despite expectations that a 50% decline in the price of West Texas Intermediate (WTI) would prompt sharp drops in US crude oil production, the first leg of the current downturn struck its most significant blows on US rig counts and day rates, as production continued to increase into second-quarter 2015 when WTI staged a 25% price rally.

While this price rebound may appear illogical, a rally often occurs after prices have fallen sharply during the first leg of a bear market. Unsurprisingly, then, after the rebound ran its course, WTI prices continued to fall to a 1-day low of $27/bbl in mid-February 2016.

After a lag of 6-8 months, US crude production finally responded to the accelerating decline in the oil-directed rig count, which fell 567 units (140%) from February to March 2015, according to Baker Hughes. After staging a short recovery in July-August 2015, the rig count began to decline steadily from September to average only 384 by March 2016, or 41% lower than the May-September 2015 average of 654.

While Petral Consulting Co. (PCC) accurately concluded at the time that US oil exploration companies eliminated all drilling activity in marginal areas of various plays and basins, drilling continued in sweet spots such as West Texas and the Bakken shale to account for the slow and uneven shift from rising to declining overall production.

As US crude oil production continues to fall during 2016 and 2017, the concurrent drop in associated natural gas volumes—the basis for US NGL output in the most important producing regions of West Texas, Kansas-Oklahoma, and the Rocky Mountains—will drive a decline in gas-plant NGL production.

From the perspective of US midstream infrastructure operators, however, an imminent surge in ethane demand before yearend 2016 will position it as a crucial element of international NGL trade, prompting immediate requirements for increased ethane recovery.

NGL raw-mix production

Gas-plant NGL production is the primary driver for most of the midstream industry's infrastructure expansion projects. Growth in crude oil production and resulting increases in associated gas production have been, and will remain, the primary drivers of gas-plant NGL production trends.

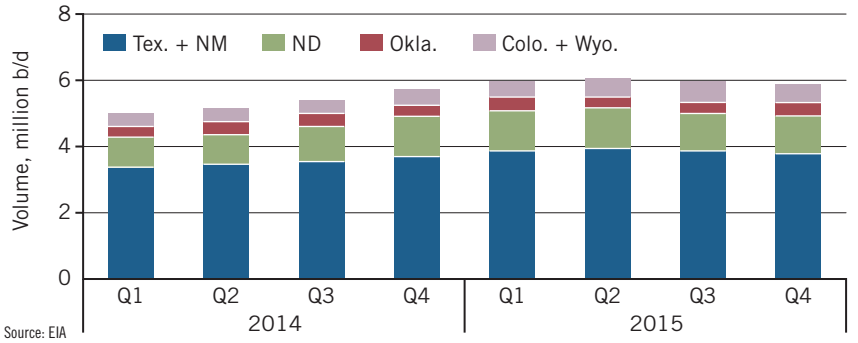
Statistics from the US Energy Information Administration (EIA) showed year-on-year growth in US crude production of 1.30 million b/d in fourth-quarter 2014 but 1.26 million b/d in first-quarter 2015 and 0.99 million b/d in the second quarter (Fig. 1). Slowing growth rates for US crude oil production shifted to outright declining production in first-quarter 2016. PCC estimates US production for the first quarter was 9.08 million b/d, or 0.23 million b/d less than in first-quarter 2015.

Table 1 summarizes quarterly trends in US crude oil production.

PCC estimates associated gas production in the six core states (Texas, New Mexico, Kansas, Oklahoma, Wyoming, and Colorado) during first-half 2015 increased to 13.4 bcfd from 12.3 bcfd in second-half 2014. Associated gas production remained constant at 13.4-13.5 bcfd in second-half 2015, but PCC forecasts production will fall to 12.5-12.7 bcfd in 2016.

CRUDE OIL PRODUCTION, SELECTED STATES

FIG. 1



Source: EIA

Regional trends

US gas plant NGL production continued to increase in second-half 2015. In third-quarter 2015, gas-plant NGL production rose to 3.32 million b/d, or 225,100 b/d higher compared with the same quarter in 2014, according to EIA data. During fourth-quarter 2015, production volumes increased to 3.41 million b/d, or 306,000 b/d more than in fourth-quarter 2014.

Changes in ethane rejection, however, have significant impact on annual growth in US NGL volumes, and trends in propane+ production provide a clearer view of year-over-year growth in NGL output.

Production of propane+ in third-quarter 2015 grew by 227,100 b/d from the same period a year earlier to 2.23 million b/d but fell to 2.22 million b/d in fourth-quarter 2015, which was down by 189,800 b/d from the final quarter of 2014 (Table 2).

US CRUDE OIL PRODUCTION

Table 1

2015-16	Tex.-NM	ND	Okla.	Colo.-Wyo.	All others	Total
	1,000 b/d					
1 Qtr.	3,913.8	1,186.0	360.0	508.5	3,349.8	9,318.0
2 Qtr.	3,964.8	1,203.0	357.0	562.6	3,415.5	9,503.0
3 Qtr.	3,847.5	1,176.0	327.0	592.6	3,392.7	9,335.8
4 Qtr.	3,776.2	1,157.0	408.0	561.4	3,406.6	9,309.2
1 Qtr.*	3,673.2	1,103.0	395.0	538.8	3,373.5	9,083.5

*Petral Consulting Co. estimates.
Source: EIA Petroleum Supply Monthly

US GAS-PLANT NGL PRODUCTION

Table 2

2015-16	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	Total
	1,000 b/d					
1 Qtr.	237.2	635.0	1,822.3	324.0	69.8	3,088.3
2 Qtr.	283.3	691.6	1,904.8	327.6	67.7	3,275.1
3 Qtr.	293.8	696.6	1,950.0	316.5	58.5	3,315.4
4 Qtr.	292.0	761.9	1,964.0	326.8	68.6	3,413.3
1 Qtr.*	316.9	743.7	1,874.2	323.9	68.9	3,327.6

*Petral Consulting Co. estimates.
Source: EIA Petroleum Supply Monthly

NGL production from new gas plants in eastern Ohio's Utica shale during second-half 2015 contributed to substantial growth in overall US Midcontinent production. Production from gas plants in the eastern Upper Midwest was 163,200 b/d in third-quarter 2015, or 12,100 b/d higher from the same quarter in 2014, according to EIA data. During fourth-quarter 2015, production increased to 195,600 b/d for a year-over-year increase of 45,500 b/d. Ethane rejection limited growth in overall NGL production in third-quarter 2015 but contributed to stronger growth in the fourth quarter.

Excluding rising ethane production, NGL production from gas plants in the Marcellus shale remained nearly flat in second-half 2015 compared with the first 6 months of the year. Production was 201,600 b/d in third-quarter 2015 and 195,300 b/d in the fourth quarter, according to EIA (Fig. 2).

Ethane rejection, NGL raw mix production

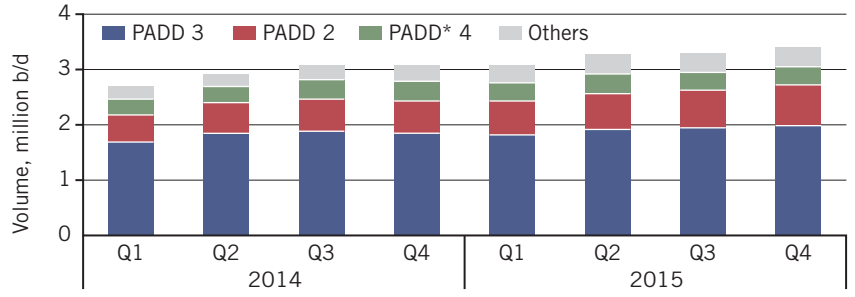
Spot prices for purity ethane and ethane-propane mix in Mont Belvieu, Tex., during third-quarter 2015 remained well below levels that would support full ethane recovery. Spot prices in Mont Belvieu were generally 18-19¢/gal in second-half 2015. PCC estimates recovery costs were 25-35¢/gal in primary producing regions (Texas-New Mexico, Kansas-Oklahoma, and Wyoming-Colorado) and 45-55¢/gal in the Marcellus, Utica, and Bakken shales.

Recovery margins also remained well below breakeven levels in third-quarter 2015, with ethane rejection reaching a peak of 650,000 b/d for the quarter, according to PCC estimates.

While a decline in natural gas prices during early fourth-quarter 2015 weakened recovery costs to 21-22¢/gal for gas plants in the Texas-New Mexico and Kansas-Oklahoma regions, recovery margins in Texas-New Mexico subsequently improved enough for gas processors to increase ethane recovery at some gas plants. PCC estimates ethane rejection

US GAS-PLANT NGL PRODUCTION

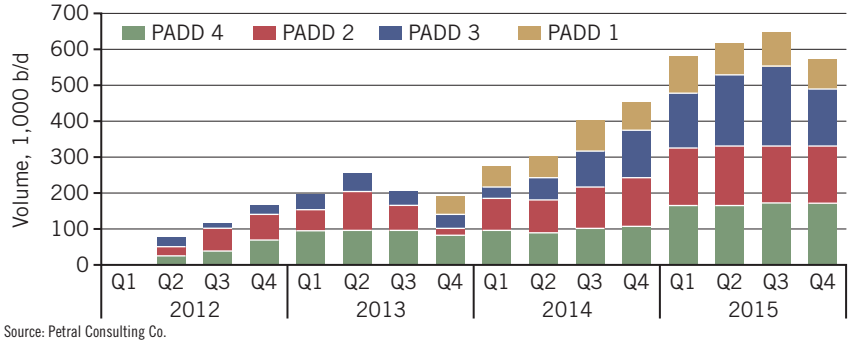
FIG. 2



*See OGJ, June 2, 2014, p. 96, for explanation of PADDs.
Source: EIA

GAS-PLANT ETHANE REJECTION

FIG. 3



Source: Petral Consulting Co.

US ETHYLENE FEEDSTOCK DEMAND

Table 3

2015-16	Ethane	Propane	n-Butane	Pentane+	Total
			1,000 b/d		
1 Qtr.	1,035.5	382.3	72.9	28.1	1,518.9
2 Qtr.	1,085.5	363.7	89.5	28.8	1,567.5
3 Qtr.	1,114.5	377.3	96.1	37.8	1,625.7
4 Qtr.	1,166.0	392.1	68.2	48.5	1,674.9
1 Qtr.*	1,171.0	382.0	74.0	47.0	1,674.0

*Petral Consulting Co. estimates.
Source: Petral Consulting Co. monthly survey

fell to 525,000-550,000 b/d in November-December 2015 (Fig. 3).

If gas processors had operated all gas plants at full ethane-recovery mode, total US NGL production would have been 3.95-4.00 million b/d in second-half 2015.

By mid-2017, petrochemical companies will complete construction of several new ethylene plants (OGJ, July 6, 2015, p. 74). Enterprise Products Partners LP (EPP) will also complete its ethane export terminal at Morgan's Point, Tex., in second-half 2016 (OGJ, June 6, 2015, p. 79).

During third-quarter 2016 through yearend 2017, feedstock demand for ethane and ethane exports will increase by 400,000-500,000 b/d.

By mid-2017, US gas plants in core producing regions (Texas-New Mexico, Kansas-Oklahoma, and Wyoming-Colorado) will be required to operate in full ethane-recovery mode to meet rising demand.

NGL market overview

Three markets account for more than 90% of US NGL demand:

- Petrochemical feedstock.
- Gasoline blending.
- Retail space heating, internal combustion.

All five NGL components are used as feedstock in petrochemical production, and normal butane, isobutane, and natural gasoline are used in gasoline blending. Retail space heating and internal combustion-engine markets, however, consume only propane. Of the three primary domestic end-use markets, only the petrochemical industry has the potential to considerably increase domestic NGL consumption. During 2017-19, petrochemical companies will start up a minimum of 15 billion lb/year of new ethylene capacity, almost all of which will be based on purity-ethane feedstock.

PCC estimates ethylene feedstock demand by direct contact with ethylene producers. Other segments of the petrochemical industry include propane dehydrogenation (propane), methyl tertiary butyl ether (MTBE; normal butane and isobutane), and propylene oxide (isobutane).

NGL demand in the ethylene feedstock market was 1.63 million b/d in third-quarter 2015 but increased to 1.67 million b/d in fourth-quarter 2015. PCC estimates demand was again 1.60-1.70 million b/d in first-quarter 2016. Demand in third-quarter 2015 was 128,000 b/d more than in third-quarter 2014. Year-to-year growth in demand, however, increased to 162,000 b/d in fourth-quarter 2015. Demand for NGL feedstock increased during second-half 2015 because these feeds continued to provide ethylene producers with lower production costs vs. refinery naphtha and gas oil.

Ethane accounted for 68-70% of ethylene industry NGL feedstock demand in second-half 2015. Ethane was responsible for 76% of growth in NGL feedstock demand during third-quarter 2015 and 87% in the fourth quarter (Table 3).

Gasoline blending demand

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US REFINERY GASOLINE BLENDING Table 4

2015-16	n-Butane	Isobutane	Natural gasoline	Total
		1,000 b/d		
1 Qtr.	205.1	173.8	129.2	508.0
2 Qtr.	57.3	191.7	122.3	371.3
3 Qtr.	91.5	216.6	144.9	453.0
4 Qtr.	272.0	207.4	127.7	607.1
1 Qtr.*	221.5	186.0	141.0	548.5

*Petral Consulting Co. estimates.
Sources: EIA Petroleum Supply Monthly, Petral Consulting Co. adjustments

mercial market for NGLs. As is true for propane demand in retail markets, refinery demand for normal butane is strongly seasonal but demand for isobutane and natural gasoline is only moderately seasonal.

Refinery demand for normal butane reaches its seasonal peak November through January, while refinery demand for isobutane and natural gasoline is usually at its seasonal peak May through August. The counter-cyclical nature of refinery demand for isobutane and natural gasoline offsets some of the strongly seasonal demand for normal butane.

During the winter RVP season, refinery butane demand historically varied little from one winter to the next. Growing surpluses of ethane, propane, and normal butane, however, increasingly have resulted in weakening prices, prompting refineries—first at the US Gulf Coast and then in other regions—to make adjustments to gasoline blends during the winter months to take advantage of weaker normal butane prices.

In winter 2010, EIA data show inputs of gas plant normal butane into Gulf Coast refineries were 16.8 million bbl and remained near this level through winter 2012. Beginning to rise in winter 2013, Gulf Coast demand reached 23.9 million bbl in winter 2015.

At US East Coast refineries in winter 2010, normal butane demand was 2.2 million bbl, which began to rise incrementally starting in winter 2012 to reach 7.0 million bbl during winter 2015, according to EIA statistics.

For unknown reasons, however, RVP blending demand for gas-plant normal butane in the US Midcontinent remained almost flat 2010-15, within a range of 8.5-9.5 million bbl, EIA data show.

EIA statistics for refinery inputs show demand for butanes and natural gasoline was 453,000 b/d in third-quarter 2015 before increasing to 607,100 b/d in the fourth quarter. In first-quarter 2016, PCC estimates demand was 540,000-550,000 b/d.

According to EIA statistics, refinery inputs of gas-plant normal butane were 91,500 b/d in third-quarter 2015 and increased to 272,000 b/d in the fourth quarter.

EIA statistics show refinery inputs of isobutane increased to a new record high of 216,600 b/d in third-quarter 2015. As typically occurs during the winter months, refinery demand for isobutane fell to 207,400 b/d during fourth-quarter 2015 amid seasonal reductions in refinery crude runs and fluid catalytic cracking unit (FCCU) feed rates. PCC estimates demand continued to fall in first-quarter 2016 to 180,000-190,000 b/d alongside still-reduced crude runs and FCCU feed rates as US refineries carried out ongoing seasonal maintenance.

The factors that determine refinery demand for natural gasoline differ from demand drivers for normal butane and isobutane. PCC's ongoing economic analysis indicates refineries primarily seek natural gasoline for use as supplemental feed to pentane-hexane isomerization units. While some refineries have these units, many do not. This consideration results in demand variability that is not seasonal but instead more or less random. During third-quarter 2015, refinery demand for natural gasoline was 144,900 b/d before falling to 127,700 b/d in the fourth quarter, according to EIA statistics (Table 4).

Retail markets, NGL exports

Retail markets consume propane in four primary end-use segments:

- Residential, commercial, and resellers (space-heating markets).
- Agriculture.
- Motor fuel.
- Miscellaneous industrial.

Of these four segments, consumption in the residential-commercial sector typically accounts for 75-80% of total demand in the retail market. Unfortunately for propane retailers, winter 2015 was even milder than winter 2014. PCC estimates propane demand in all-end use sectors was just 590,000-600,000 b/d in fourth-quarter 2015 and 880,000-900,000 b/d in first-quarter 2016.

Demand in fourth quarter 2015 was 140,000-150,000 b/d (13-14 million bbl) less than in fourth-quarter 2014. Winter weather remained milder in first-quarter 2016, leaving demand 110,000-130,000 b/d (10-12 million bbl) less than in the same period of 2015. PCC estimates retail propane demand in winter 2015 was 23-26 million bbl less than winter 2014.

Waterborne exports continued to gain importance in 2015 as an outlet for surplus US LPG supply. According to statistics published by the US International Trade Commission (USITC), NGL exports (LPG exports + ethane and natural gasoline exports) topped 1 million b/d in third-quarter 2015 and remained above 1 million b/d in fourth-quarter 2015. Total NGL exports in the third quarter were 1.03 million b/d, or 292,000 b/d more than in third-quarter 2014. In fourth-quarter 2015, NGL exports were 1.01 million b/d, 239,000 b/d more than the last quarter of 2014. PCC estimates NGL exports increased to 1.14 million b/d in first-quarter 2016, which was 300,000 b/d more than first-quarter 2015.

Propane exports accounted for 63% of total NGL exports in third-quarter 2015 and 68% in the fourth quarter, with exports in January and February 2016 jumping to 861,000 b/d. Detailed statistics published by USITC show propane exports to destinations in Asia Pacific were 357,000 b/d in January 2016 and increased to 459,000 b/d in February 2016, with all exports to the region originating from export terminals on the Texas Gulf Coast. Exports to Asia Pacific accounted for 45% of total exports in January and increased to 57% in February. Exports of propane to Asia Pacific from Texas Gulf Coast terminals in January 2016 were 303,000 b/d more than in January 2015, with exports in February 209,000 b/d more than in February 2015.

US NGL EXPORTS

Table 5

2015-16	Ethane	Propane	Butane	gasoline	Total
	1,000 b/d				
1 Qtr.	64.6	541.7	64.5	181.2	852.0
2 Qtr.	70.0	586.9	101.0	164.2	922.0
3 Qtr.	58.8	653.4	117.8	204.5	1,034.4
4 Qtr.	66.0	682.8	99.8	160.5	1,009.1
1 Qtr.*	85.0	804.0	66.0	185.2	1,140.2

*Petral Consulting Co. estimates.
Source: USA Trade Online; EIA; Petral Consulting Co. estimates

US butane exports also continued to increase during second-half 2015 but not at propane's breakneck pace. Total butane exports to all destinations were 117,800 b/d in the third quarter, or 12,100 b/d more than in third-quarter 2014, while exports during fourth-quarter 2015 were 99,800 b/d, or 40,400 b/d higher compared with fourth-quarter 2014. PCC estimates butane exports fell to 65,000-70,000 b/d in first-quarter 2016, nearly unchanged from the same period in 2015 (Fig. 5).

EIA statistics showed US ethane exports to Canada of 58,800 b/d in third-quarter 2015, increasing to 66,000 b/d in the fourth quarter. While ethane exports historically have moved only to Canada, increased demand from overseas has spurred preparations for rising US ethane exports to destinations in Europe and Asia Pacific. Sunoco Logistics Partners LP completed commissioning a cryogenic storage and export terminal at Marcus Hook, Pa., in first-quarter 2016, loading its first shipment for export to Norway in March (OGJ Online, Mar. 11, 2016). EPP is scheduled to complete its ethane export terminal at Morgan's Point before year-end 2016 (OGJ Online, Nov. 11, 2015). In 2017, US ethane exports to ethylene producers in Europe and India will surge to 100,000-200,000 b/d.

Midstream infrastructure

NGL midstream companies historically have built and operated four basic elements of infrastructure:

- Gas processing plants.
- Raw mix purity-product transportation systems.
- Fractionators.
- Storage.

The midstream industry has typically focused all its resources and management efforts on expanding capacity in the first three elements but made no investment in expanding NGL storage and affiliated infrastructure. As US NGL supplies have increased to chronic surplus, however, a few midstream companies have expanded the industry's fifth element: LPG import-export terminals.

Export terminals were one of the industry's critical bottlenecks until second-half 2015. As with other major elements of midstream infrastructure, export terminal capacity was inadequate to meet the industry's rapid 2010-15 growth of propane and butane surpluses. In 2010, US midstream companies had LPG import terminals at several East Coast locations; two merchant LPG import-export terminals in the Houston Ship Channel; and two privately operated LPG import terminals in Louisiana and Texas. The export capacity at existing Houston Ship Channel sites was about 180,000 b/d in 2010. An idle facility in the Corpus Christi area was reactivated 2010-12, boosting total capacity along the Texas Gulf Coast to 230,000 b/d by yearend 2012.

As with other major elements of midstream infrastructure, midstream companies expanded the capacity of existing export terminals and launched new build projects during 2011-15. By year-end 2016, five companies (EPP, Occidental Chemical Corp., Phillips 66, Sunoco Logistics, and Targa Resources Partners LP) will have operational LPG export terminals on the Texas Gulf Coast. Based on information from company press releases and regulatory filings, the combined nominal capacity of LPG export terminals in the region was 925,000-950,000 b/d in late 2014 or early 2015. By yearend 2016, this will reach 1.2 million b/d.

During 2010-12, refrigeration capacity of export terminals at the Texas Gulf Coast was sufficient to accommodate the exportable surplus. Exports were 99,800 b/d in 2010, 109,800 b/d in 2011, and 155,600 b/d in 2012. In 2010 and 2011, the single-month maximum export rates were 128,000 b/d and 160,100 b/d, respectively. US ITC statistics showed Gulf Coast (all customs districts, including overland sites) propane exports spiked to 216,200 b/d in November 2012. Based on Customs District details, propane exports from the Houston-Galveston Customs District (which extends to Corpus Christi) were 197,600 b/d in November and 182,000 b/d in December.

Capacity was constrained 2013-14. As terminal operators completed each incremental expansion, LPG exports increased immediately. When nominal capacity at the Texas Gulf Coast reached 950,000 b/d in early 2015, however, capacity stopped being a limitation. LPG exports were 429,000 b/d in 2014 with the single-month maximum in December

2014 of 535,000 b/d. In 2015, LPG exports from Texas Gulf Coast terminals increased to 612,800 b/d with the single-month maximum of 752,000 b/d in December 2015.

Two companies also have operational East Coast LPG export terminals. Sunoco Logistics operates at Marcus Hook, and DCP Midstream at Chesapeake, Va. By yearend 2016, combined capacity of East Coast LPG export terminals will be about 300,000 b/d.

Price trends, profitability

PCC tracks gas processing economics based on netback values of NGL raw mix for gas plants in Texas, New Mexico, and the Rocky Mountains. Gas plants in these regions are the primary sources of NGL raw mix deliveries to NGL fractionators in Mont Belvieu.

Gas plant NGL production continued to increase in second-half 2015, but demand in domestic markets remained almost stagnant. Spot prices in Mont Belvieu for propane, butanes, and natural gasoline fell to levels not seen since 2002.

PCC estimates the weighted-average price of NGL raw mix in Mont Belvieu was 41¢/gal ($3.91/MMbtu) in third-quarter 2015. Prices recovered to 43¢/gal ($4.04/MMbtu) in fourth-quarter 2015 but fell to 37¢/gallon ($3.44/MMbtu) in first-quarter 2016.

Historically, competition among various feedstock options available to ethylene plants along the Texas-Louisiana Gulf Coast has been the paramount influence on Mont Belvieu NGL prices. While competitive economics in the Gulf Coast ethylene industry remain an important influence, the role of international markets has grown.

As US NGL exports expanded during 2013-15, pricing in Northwest Europe and Northeast Asia as well as international freight rates became more important influences on Mont Belvieu NGL pricing. Terminal fees for the new export terminals in the Texas Gulf Coast are 12-15¢/gal, with producer-exporters in the Middle East and North Africa able to operate without such fees. Freight rates from Houston to Japan also are consistently higher than from the Middle East to Japan. PCC views Gulf Coast terminal fees to be a fixed cost, but international freight rates vary with the availability of vessels for spot-cargo shipments.

Freight rates for deepwater LPG trade in international markets rose to record highs in first-half 2015. As ship owners received new world-class LPG vessels, fright rates began a sharp decline in third-quarter 2015. Ship yards continued to deliver additional new vessels in first-half 2016, and freight rates continued to fall. As a point of comparison, freight rates from Houston to Japan were 55-60¢/gal (not including export terminal fees) but began a fall in July 2015, reaching 12-14¢/gal in February-March 2016.

More LPG vessels are slated for de-

NELSON-FARRAR COST INDEXES[1]

Refinery construction (1946 basis)
Explained in OGJ, Dec. 30, 1985, p. 145.

	1962	1980	2013	2014	2015	Feb. 2015	Jan. 2016	Feb. 2016
Pumps, compressors, etc.	222.5	777.3	2,221.1	2,271.9	2,313.6	2,306.7	2,348.3	2,334.1
Electrical machinery	189.5	394.7	516.7	515.8	516.5	516.8	513.7	513.2
Internal-comb. engines	183.4	512.6	1,046.8	1,052.9	1,062.3	1,060.3	1,034.4	1,034.4
Instruments	214.8	587.3	1,509.9	1,533.6	1,554.4	1,528.4	1,565.8	1,583.5
Heat exchangers	183.6	618.7	1,293.3	1,305.0	1,305.0	1,305.0	1,221.2	1,221.2
Misc. equip. average	198.8	578.1	1,317.5	1,335.8	1,350.3	1,343.5	1,336.7	1,337.3
Materials component	205.9	629.2	1,538.7	1,571.8	1,434.9	1,490.7	1,344.2	1,342.2
Labor component	258.8	951.9	3,123.4	3,210.7	3,293.8	3,259.8	3,341.9	3,347.6
Refinery (inflation) index	237.6	822.8	2,489.5	2,555.2	2,550.2	2,552.2	2,542.8	2,545.4

Refinery operating (1956 basis)
Explained in OGJ, Dec. 30, 1985, p. 145.

	1962	1980	2013	2014	2015	Feb. 2015	Jan. 2016	Feb. 2016
Fuel cost	100.9	810.5	1,123.7	1,264.8	915.9	946.6	832.7	837.2
Labor cost	93.9	200.5	308.3	312.8	319.2	315.4	350.9	361.5
Wages	123.9	439.9	1,506.4	1,541.3	1,584.4	1,615.1	1,642.8	1,661.6
Productivity	131.8	226.3	489.1	493.1	497.1	512.1	468.1	459.7
Invest., maint., etc.	121.7	324.8	905.3	939.4	948.0	948.8	918.0	918.9
Chemical costs	96.7	229.2	502.6	472.3	434.6	437.9	406.9	402.1
Operating indexes[2]								
Refinery	103.7	312.7	661.8	688.5	660.0	661.9	648.8	653.2
Process units	103.6	457.5	802.6	865.3	748.1	758.0	718.0	723.1

[1]*These indexes are published in the first of each month and are compiled by Gary Farrar, OGJ Contributing Editor.*
[2]*Add separate index(es) for chemicals, if any are used. Indexes of selected individual items of equipment and materials are also published on the Quarterly Costimating page in first issues for January, April, July, and October.*

livery over the balance of 2016, and as additional vessels come into service, downward pressure on freight rates will increase. As US LPG supply growth slows, global markets will stabilize, while prices in Northeast Asia may increase if demand continues to grow at rates similar to second-half 2015. Given that LPG freight rates are variable and sometimes change several times in any given month, this variability is an important influence on spot prices in Mont Belvieu.

Outlook

As it almost always has been, the near-term outlook for supply and pricing is a function of crude oil prices. In an ideal scenario for midstream companies, crude oil prices would remain strong and US NGL production would steadily increase to create opportunities for midstream operators to respond to the ongoing need for additional pipeline and fractionation capacity in the domestic market and to further develop export terminal capacity to meet the needs of international markets. As upstream and midstream operators realize, however, this currently is not the case.

According to the Organization of Petroleum Exporting Countries' latest monthly Oil Market Report, Saudi Arabia increased crude oil production to 10.0-10.5 million b/d in second-quarter 2015 and maintained output constant at 10.1-10.3 million b/d in both second-half 2015 and first-quarter 2016.

Just before the Doha meeting (OGJ Online, Apr. 18, 2016), Saudi Arabia reminded global oil markets that it could raise its oil production to 11.5 million b/d within a matter of weeks. The reminder had limited immediate impact on crude oil prices for the various benchmarks.

Global markets, however, have already factored gradually increasing Iranian production into near-term supply expectations. PCC previously expected prices for global crude oil benchmarks to remain in the range of $40-50/bbl during first-half 2016 (OGJ, Nov. 2, 2015, p. 70). While a minor panic regarding US crude oil inventory and storage capacity sparked a sharp drop in crude oil prices in January and February, prices for WTI and Dated Brent quickly rebounded to $40-45/bbl. This aspect of the near-term outlook remains intact.

According to EIA statistics, US crude oil production in fourth-quarter 2015 was 9.31 million b/d, an increase of about 200,000 b/d from the same quarter in 2014. US production peaked in April 2015 before falling an additional 439,000 b/d by December 2015.

Production declined more slowly than markets initially anticipated in fourth-quarter 2014 when oil prices began to fall. But the number of oil-directed rigs in service continues to decline, and the rate of decline for US production is likely to accelerate during second-half 2016 and first-half 2017.

PCC expects US NGL production to stabilize at 3.25-3.50 million b/d in second-half 2016 before increasing to 3.40-3.60 million b/d in first-half 2017 as gas processors swing gas plants from ethane rejection to full recovery in the Texas-New Mexico and Kansas-Oklahoma regions.

Domestic demand for most NGL components will remain at current levels through yearend 2016 and into first-half 2017, but startup of two 750-tonne/year propane dehydration plants will coincide with increased chemical feedstock demand for propane of 15,000-25,000 b/d in first-half 2016 and 35,000-50,000 b/d in second-half 2016 vs. second-half 2015.

Finally, PCC forecasts propane exports will stabilize at 550,000-600,000 b/d during 2016, but ethane exports will increase to 100,000 b/d before yearend 2016. Butane exports will remain within the established ranges of 2014-15. OGJ

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PROCESSING

Asphaltenes extraction treatment yields advantaged hydroprocessing feedstock

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Selective extraction of asphaltenes (SELEX-Asp) technology—a solvent-based physical separation process capable of selectively removing asphaltenes as dry granulates in heavy crude oils and petroleum residue—has emerged as an alternative treatment option that could deliver cleaner, higher-quality feedstock immediately usable across multiple processing units (OGJ, Apr. 5, 2010, p. 52).

A series of follow-up tests at existing pilot and commercial-scale units in China concluded that using SELEX-Asp technology instead of traditional processes to pretreat vacuum residua (VR) derived from inferior-quality, heavy crudes also prepares a cost-friendly and environmentally compliant feedstock especially for conventional packed-bed hydroprocessing units. Direct production of this feedstock via SELEX-Asp can further maximize profitability of a refinery's existing bottoms stream as well as eliminate its need to use costlier but less-efficient coking and ebullated-bed reactor systems for feedstock pretreatment.

Background

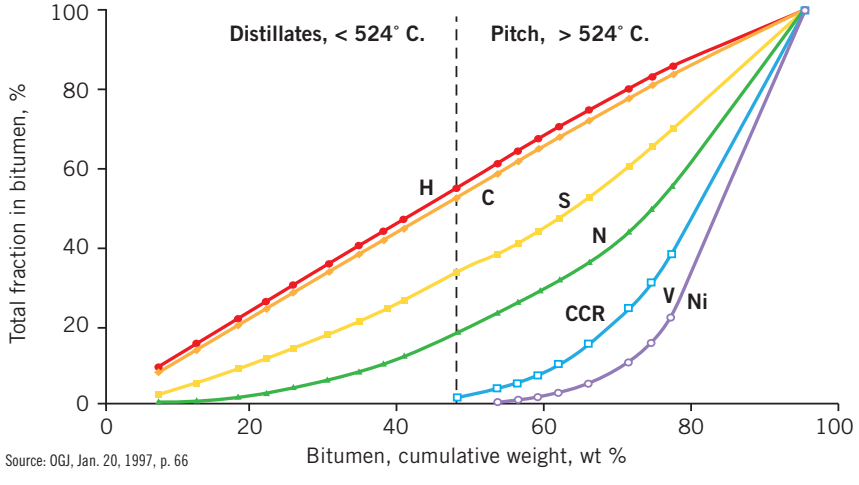
Heavy crude oils and petroleum residue contain high concentrations of contaminants that must be removed before most refining processes. While common industry practice is to use energy-intensive and costly pretreatment technologies such as coking and ebullated-bed hydroprocessing to remove most contaminants, these processes often require extended unit shutdowns and yield feedstock still unsuited for additional processing in units producing fuels that will meet today's increasingly stringent environmental regulations.[1]

In conventional refineries, fluid catalytic cracking (FCC) is the key process used to convert heavy distillates (vacuum gas oil) into transportation fuels such as gasoline, jet fuel, and diesel. Packed-bed hydrotreating and hydroprocessing units remove contaminants and enhance feedstock processability before further downstream processing.

Improvements to catalytic refining processes over the past 30 years have enhanced their ability to process heavier feedstock, which typically includes a blend of distillates as well as a certain amount of residua. Many modern refineries are equipped with resid fluid catalytic cracking (RFCC) units

KEY SPECIES, DISTRIBUTION CURVES

FIG. 1



Source: OGJ, Jan. 20, 1997, p. 66

and packed-bed resid hydroprocessing units to treat and convert low-cost, heavy feedstock into transportation fuels.

These catalytic processes, however, require stringent feedstock-quality specifications to prevent rapid catalyst deactivation and plugging of packed-bed catalysts.

For RFCC units, Conradson carbon residual (CCR) content of feedstock should not exceed 8 wt%, while total-metals content should not exceed 20 ppm.[2,3]

Feedstock with excessive CCR or total-metals contents is unsuitable for processing through packed-bed resid hydrocrackers.[3] CCR content of feedstock for this type of processing should not exceed 12 wt%, with total-metals content not to exceed 100 ppm.[4,5]

Even after subjecting heavier feedstock to conventional solvent deasphalting (SDA), the resultant deasphalted oil (DAO) still may be unsuitable for packed-bed resid hydroprocessing. It first must be blended with light crude or a lighter hydrocarbon fraction to sufficiently dilute undesirable contaminants.[6]

Residuum chemistry

The lack of adequate analytical techniques for characterizing heavy petroleum fractions makes the chemistry of petroleum residuum difficult to define and detailed quantification and correlation of resid feedstock properties to reaction process performance impossible. The use of feedstock specifications (CCR, total-metals contents) as criteria for selecting reactor systems to process various heavy crudes and residua, then, is more intuitive than scientific.[3-5]

CCR is an indicator of the amount of coke that forms when hydrocarbon samples undergo destructive distillation (OGJ, Jan. 20, 1997, p. 66). Not all CCR species in VR subfractions have the same coking propensity.[7]

Fig. 1 shows uneven distributions of CCR and metals species in VR.

Except for the CCR content present in petroleum asphaltenes, most CCR species in VR can be converted to noncoke species via hydrotreating and hydrocracking processes.[8]

Undesirable components concentrated in asphaltenes must be removed before processing remaining VR fractions in conventional refinery RFCCs and packed-bed hydroprocessing units.[9-10]

SELEX-Asp technology can selectively remove VR subfractions, including asphaltenes (OGJ, Apr. 5, 2010, p. 52) and prepared DAO's with differing amounts of asphaltenes (from trace amounts to 9 wt%), from VR's of different origins. Studies of SELEX DAO-derived asphaltenes using ultrahigh-resolution Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) concluded that their chemistry hinged on asphaltene content resulting from the selective extraction of asphaltene subfractions. Varying solvent extraction powers at critical solvent conditions created the selective extraction.[11-12]

Packed-bed hydroprocessing

SELEX DAO samples of various asphaltene contents underwent catalytic hydroprocessing screening tests. These tests involved mixing the samples with hydrogen gas and introducing the mixture to a 125-ml continuous catalyst testing unit under mild hydroprocessing conditions.

Designed in a grading-bed configuration, the testing unit contained five types of catalysts:

- Hydrodemetalization (HD metals).
- Hydrodesulfurization (HD sulfur).
- Hydrodenitrogenation (HD nitrogen).
- CCR removal (HD aromatics).
- Mild hydrocracking (MHC).

Results of pressure-drop monitoring across the packed-catalyst bed reactor showed that SELEX DAO with less than 2 wt% asphaltenes had a constant differential pressure across the catalyst bed after an 18-hr continuous run, without any sign of catalyst coking or plugging.

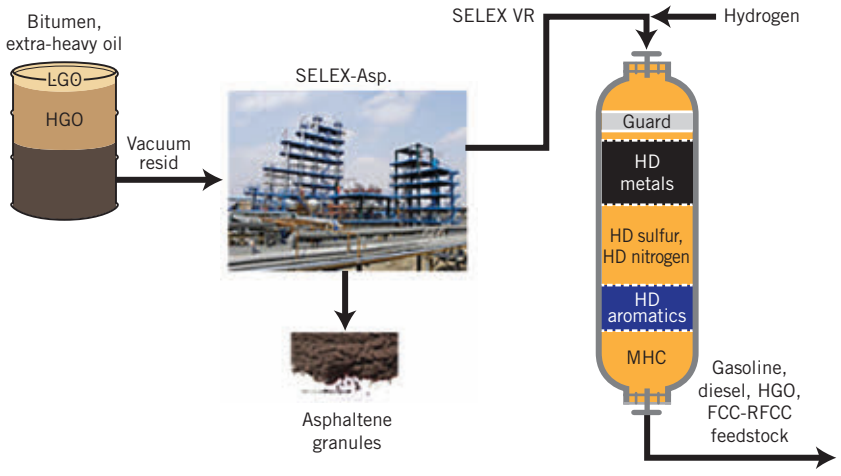
SELEX DAO with higher than 2 wt% asphaltenes showed a 50-kPa differential pressure increase across the catalyst bed after a 7-hr continuous run, indicating possible catalyst coking or plugging.

In an extreme case of SELEX DAO with 9 wt% asphaltenes, the catalyst reactor was plugged after 2 hr of operation, suggesting that SELEX DAO with higher than 2 wt% asphaltenes was not suitable for packed hydroprocessing.

Additional studies

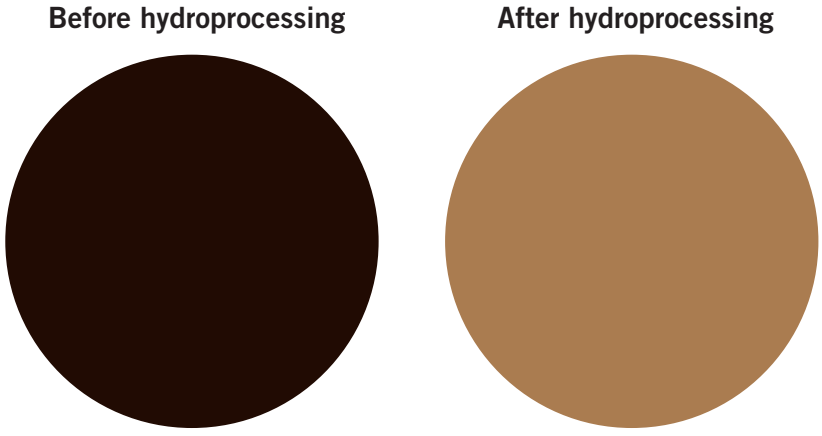
Athabasca oil sands bitumen and Ven-

PREPARING VR AS PACKED-BED HYDROPROCESSING FEED FIG. 2



SELEX-ASP VR, COLORATION

FIG. 3



BITUMEN-DERIVED VR FEED PROPERTIES

	Bitumen VR	After SELEX-Asp	Product post MHC
		Yield, wt%	
IBP-350° C.	0	0	10
350-524° C.	0	0	40
Density at 20° C., g/cu m	1.0648	0.9990	0.9486
Carbon, wt%	82.97	82.82	86.22
Hydrogen, wt%	9.65	10.43	11.53
H/C, atomic ratio	1.39	1.50	1.60
Sulfur, wt%	6.00	4.80	0.59
Nitrogen, wt%	0.68	0.51	0.36
CCR, wt%	23.3	13.0	4.2
Nickel, ppm	144	77	2
Vanadium, ppm	357	176	1
Saturates, aromatics, resins, asphaltenes (SARA) composition, wt %			
Saturates	9.31	18.99	44.80
Aromatics	43.44	56.24	43.97
Resins	21.67	24.77	11.23
Asphaltenes	25.58	Not detectable	Not detectable

ezuelan Orinoco extra-heavy crude served as worst-case scenarios for subsequent studies to investigate SELEX DAO's suitability as feedstock for packed-bed hydoprocessing units.

Fig. 2 shows the processing steps used to prepare these VRs as feedstock for packed-bed hydroprocessing.

Canadian bitumen

Testing of a bitumen-derived VR obtained from a commercial oil sands plant in Fort McMurray, Alta., occurred at a 1-b/d continuous pilot-scale SELEX-Asp unit at the China State Key Laboratory of Heavy Oil Processing, Beijing.

Adjusting the SELEX-Asp process operating parameters ensured removal of all pentane-insoluble asphaltenes as solid granules and an asphaltene-free VR product.

While the unit removed asphaltenes equivalent to 16 wt% of oilsands bitumen, SELEX DAO still contained 13 wt% CCR and 250 ppm metals, both of which exceed packed-bed resid hydroprocessing specified feedstock-operating guidelines of 12 wt% CCR and 100 ppm metals.

Mixing the SELEX DAO with hydrogen gas occurred before introduction to a 125-ml continuous catalyst testing reactor operated under MHC conditions. The catalyst-testing reactor was a commercial apparatus packed with a guard-bed material and the five types of equilibrium catalysts (HD metals, HD sulfur, HD nitrogen, HD aromatics, and MHC) in a grading-bed configuration.

Feeding the reactor unit continuously for 1,500 hr with a similar-quality feed derived from extra-heavy crude preceded the SELEX DAO's resid-hydroprocessing run, allowing catalysts in the reactor to be at an equilibrium state when the SELEX DAO-hydrogen mixture entered the unit.

The continuous packed-bed hydroprocessing run with SELEX DAO also lasted for 1,500 hr, with no observable sign of pressure drop across the catalyst bed. Results showed no catalyst-bed plugging, even though the SELEX DAO feedstock contained relatively high CCR (13 wt%) and metals (250 ppm) concentrations.

A gas-liquid separator divided the reaction product into gas and hydroprocessed liquid that were sampled for analysis daily.

The accompanying table shows the properties of bitumen-derived VR before and after SELEX-Asp treatment as well as SELEX DAO products' properties following MHC.

Test run results showed a dramatic improvement in the properties of bitumen-derived VRs following SELEX-Asp treatment and subsequent packed-bed hydroprocessing of SELEX DAO, including a yield of 10 wt% diesel and 40 wt% heavy gas oil (HGO) based on simulated distillation.

SELEX DAO also yielded a much lighter reaction liquid following MHC (Fig. 3).

Most importantly, the reaction liquid product contained 4 wt% CCR, 3 ppm metals, and 45 wt% saturated hydrocarbons, all of which are characteristics of superior catalytic cracking feedstock.

Venezuelan Orinoco

A separate investigation tested SELEX DAO derived from extra-heavy Orinoco crude obtained from PetroChina's refinery near Liaohe oil field, which is equipped with a commercial-scale SELEX-Asp unit (OGJ, Apr. 5, 2010, p.

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52).

This study adjusted SELEX-Asp operating parameters to yield SELEX DAO containing 1.3 wt% pentane-insoluble asphaltenes as well as high concentrations of CCR (13.5 wt%) and metals (280 ppm). Ultrahigh-resolution FT ICR-MS analysis showed that SELEX DAO asphaltene (1.3 wt%) chemistry was not the same as typical DAO asphaltenes derived from conventional SDA processes, likely because a liquid-liquid extraction SDA system made the entrained DAO asphaltenes nonselective. SDA DAO asphaltenes have an established history of causing catalyst coking and plugging of packed-catalyst beds.

The Orinoco-derived SELEX DAO ran through the same 125-ml continuous catalyst testing reactor after being mixed with hydrogen gas. The unit operated under MHC conditions and was packed with a guard-bed material as well as the five fresh catalysts (HD metals, HD sulfur, HD nitrogen, HD aromatics, and MHC) in a grading-bed configuration.

Before resid-hydroprocessing the reactor unit went through presulfiding with 2% carbon disulfide in cyclohexane for 72 hr, followed by precoking with VGO derived from Chinese Daqing crude for 48 hr. The continuous packed-bed resid hydroprocessing run with SELEX DAO took 1,300 hr.

The resid hydroprocessing run varied both the operating pressure and liquid hourly space velocity (LHSV), with the temperature kept constant.

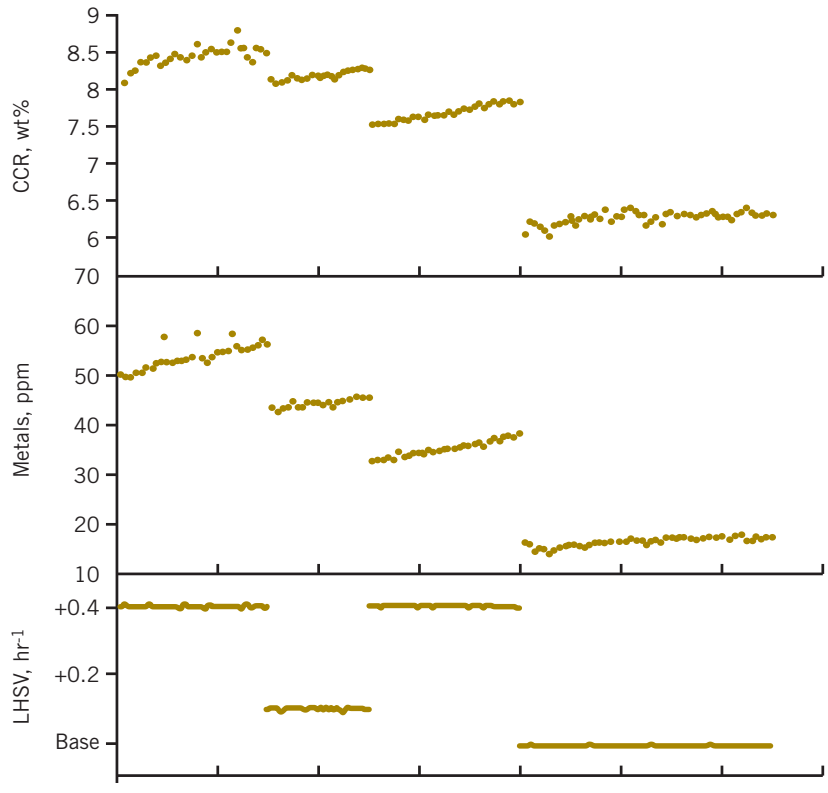
Fig. 4 shows the online process performance data and concentrations of CCR and metals from the run's daily reaction product samples.

The reactor ran at base pressure for its first 500 hr, later increased to base +4 MPa pressure. Test results showed relatively constant reactor pressure, with no pressure-drop build-up observed across the catalyst bed for the run's duration.

Removal of CCR and metals depended on reaction severity, with high reaction severity (high pressure and low LHSV) increasing removal.

MILD HYDROCRACKING PILOT*

FIG. 4



The slopes of CCR and metals concentrations of daily reaction products showed high-reaction pressure reducing the catalyst deactivation rate. Results generally verified that even though SELEX DAO is a heavier feedstock, it performs similarly to VGO during resid hydroprocessing.

Results overview

The catalyst systems used in both tests were not optimized and commercial packed-bed residuum desulfurization (RDS) unit specifications for processing "cleaner" feedstock (containing less than 12 wt% CCR and 100 ppm metals) provided the basis for selecting mild hydroprocessing conditions for continuous pilot testing of SELEX DAOs.[5] RDS units, however, require replacement of HD metals catalyst after 3-4 months of service due to coking and bed plugging.

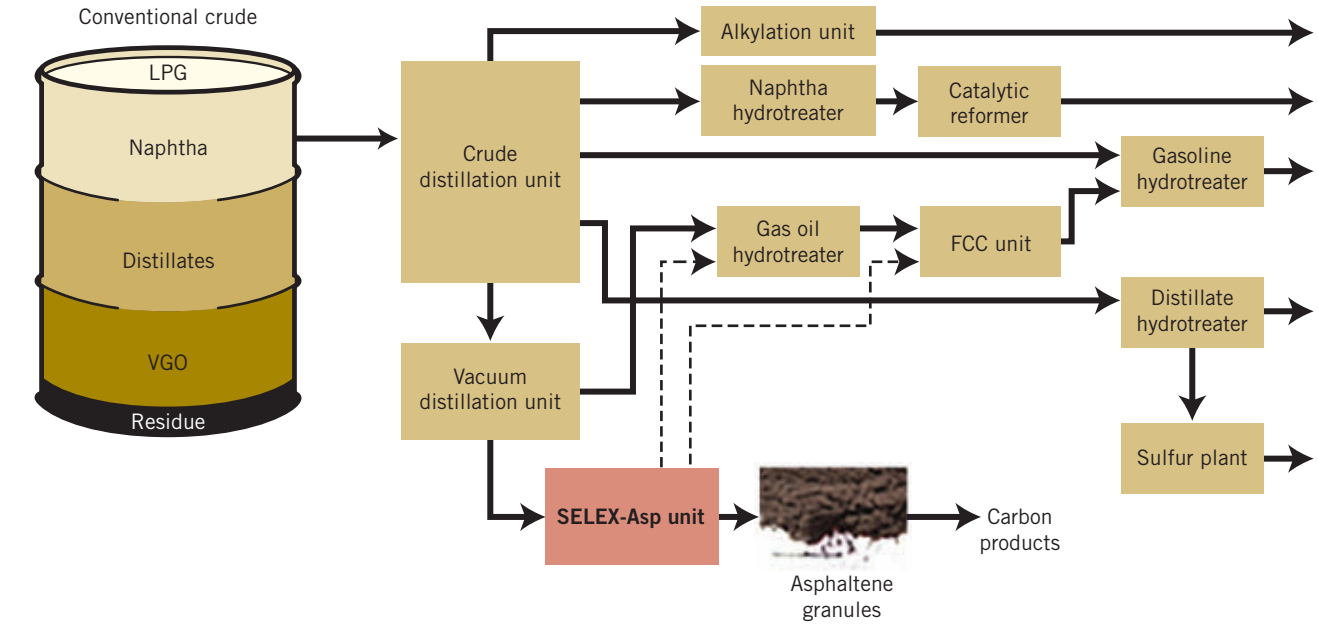
SELEX DAOs containing higher concentrations of CCR and metals, however, showed no signs of pressure-drop build-up across the catalyst bed after more than 2 months of operation. Moreover, if catalyst coking and bed plugging had occurred, pressure-drop build-ups across the packed-catalyst bed likely would have been more severe in a pilot-scale reactor system than a commercial-scale system. The studies demonstrated that SELEX DAO perform better and more economically than traditionally derived VRs as feedstock for packed-bed hydroprocessing as a result of the longer catalyst-service cycle.

Results also confirmed that conventional packed-bed resid hydroprocessing of VR's derived from SELEX-Asp pretreatment further increases the volume and quality of potential feedstock suitable for other refinery processes downstream of the hydroprocessor, eliminating the need to use coking or ebullated-bed reactor systems for feedstock pretreatment.

Results also pointed to the need to

LOW-COST CAPACITY EXPANSION

FIG. 5



revise currently less-than-sophisticated feedstock-specification guidelines used by the industry to select reactor systems,[2-5] incorporating actual feedstock-characterization data obtained from advanced analytical techniques.[11]

Applications

It is common practice in the refining industry to design and construct a processing unit 10-15% larger than its planned operating capacity. This additional capacity, in most cases, is not used.

The studies discussed in this article offer further evidence that adding a commercial-scale SELEX-Asp unit at a typical conventional refinery (Fig. 5), such as North Huajin Chemical Industries Group Corp.'s in Panjin, creates a low-cost and simple means of expanding its overall operating and production capacities.

VRs and bottom streams such as fuel oil that otherwise would be discarded now serve as feedstock for SELEX-Asp treatment to produce feedstock for further processing. Since processability of SELEX-DAO mirrors that of VGO, the refinery can capitalize on spare capacity of existing units (gas oil hydrotreater, RFCC) to process SELEX-DAO and increase yields of more valuable fuel streams without having to purchase additional feedstock.

With only a small amount of low-value solid asphaltenes left over, disposal costs also are minimized.

Refinery flexibility

The studies discussed in this article also confirmed SELEX-Asp's ability to expand a refinery's flexibility to process unconventional heavy crudes more economically by averting the need to use costlier cokers and ebullated-bed reactor systems to pretreat the more contaminated cuts derived from these crudes.

Fig. 6 shows the compositions of benchmark crudes Arabian Light (36° API gravity), Arabian Heavy (26° API gravity), and oil sands bitumen (8° API gravity), before and after SELEX-Asp treatment.

As a crude gets heavier, its residuum content (524° C.+ fraction) increases. For untreated crudes, the amount of native residua (shown in red) varies slightly. The amount of asphaltenes (shown in black), however, differ sharply (1 wt% Arabian Light, 9.5 wt% Arabian Heavy, and 16 wt% oil sands bitumen), highlighting asphaltene removal as the key problem of residuum processing.

Benchmark crudes treated by SELEX-Asp technology in ongoing tests have shown removal of residua contaminants sharply increases the amount of VGO (shown in blue) feedstock that is well-prepared for further downstream processing.

At current global crude-consumption rates of 95 million b/d, the authors estimate SELEX-Asp processing technology could provide conventional refineries an additional 5 million b/d of feedstock for production of cleaner fuels. OGJ

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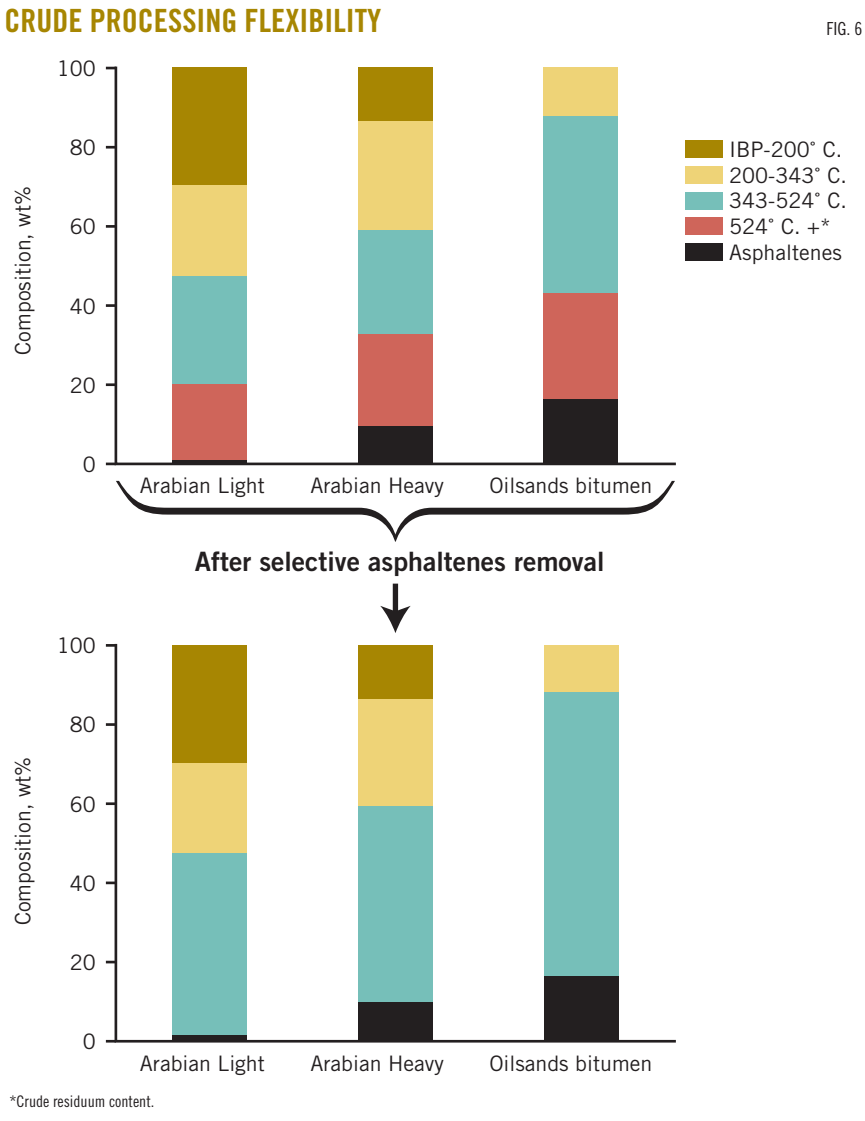

*Crude residuum content.

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FERC Bear Head, Jordan Cove rulings offer LNG market guidance

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The US Federal Energy Regulatory Commission's (FERC) Bear Head and Jordan Cove decisions highlight the difficulties LNG applicants face when dealing with FERC's and the Department of Energy Office of Fossil Energy's (DOE/FE) discretionary authority under the Natural Gas Act (NGA). Applicants have no control over the agencies' decision-making processes, but can proactively shape their permitting strategy to mitigate the potential for a negative outcome. Applicants must engage the agencies and other stakeholders early in project development and must understand the political climate in which deliberations are occurring.

On Feb. 5, 2016, the DOE/FE issued orders to Bear Head LNG Corp. and Bear Head LNG (USA) LLC both authorizing the export of US-sourced natural gas from Canadian LNG plants to countries with which the US does not have a free-trade agreement (non-FTA nations)[1] and disclaiming NGA Section 3 jurisdiction over shipments of Canadian natural gas travelling by pipeline through the US on its way back to Canada (in-transit shipments).[2] Both decisions tackled issues of first impression, announcing DOE's comprehensive policy for considering applications that involve LNG exports from Eastern Canada to global markets.

Mar. 11, 2016, FERC denied Jordan Cove Energy Project LP's application to site, construct, and operate an LNG export plant at Coos Bay, Ore.,[3] the first time FERC rejected an LNG export plant. Denial of the Jordan Cove terminal was not predicated on a finding of inconsistency with the public interest. FERC instead denied the associated pipeline and reasoned that "without a pipeline connecting [the terminal] to a source of gas to be liquefied and exported, the proposed Jordan Cove LNG terminal can provide no benefit to the public to counterbalance any of the impacts which would be associated with its construction."[3]

These orders, addressing projects from the East Coast of Canada and the US West Coast, point out what might be the most significant legal maxim currently affecting the LNG industry: both DOE/FE and FERC possess (and exercise) significant, discretionary authority under the NGA. Bear Head showcases a favorable outcome in circumstances where the agency had no established guiding policy or applicable procedures for processing applications. Jordan Cove, by contrast, exposes how an LNG export application may be denied even when longstanding policy favors the development of LNG infrastructure. This article examines the lessons learned and policy considerations revealed by both proceedings as they relate to LNG projects across North America.

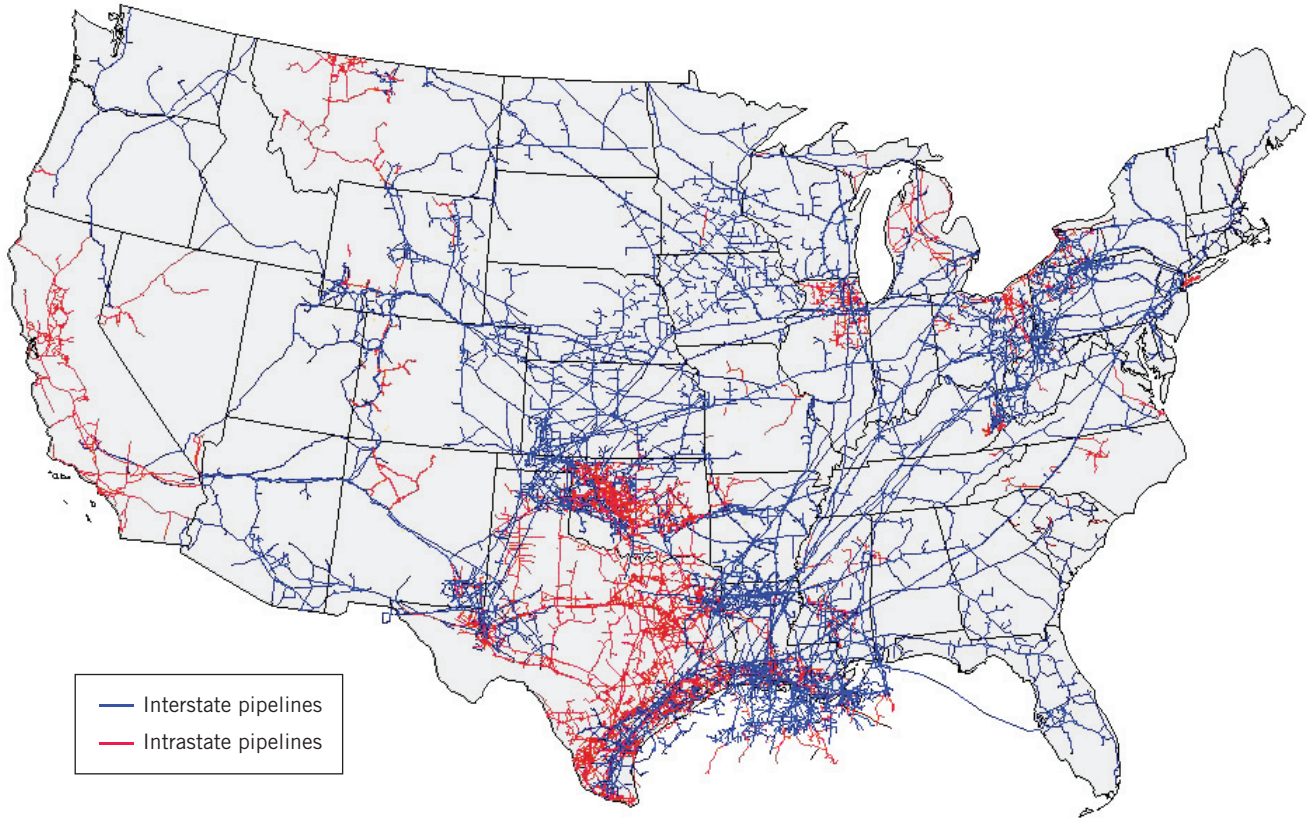
Bear Head

In Order 3769 (In-Transit Order) DOE/FE determined it lacks jurisdiction under NGA Section 3 over Bear Head LNG's proposed imports of Canadian natural gas travelling by pipeline through the US on its way back to Canada. In this regard, DOE/FE dismissed Bear Head LNG's application seeking authorization to access Western and Central Canadian natural gas supplies that necessarily must cross the US-Canada border (due to transportation pipeline configurations) en route to the proposed Bear Head LNG project. In Order 3770 (Non-FTA Order) DOE/FE granted long-term, multi-contract authorization under NGA Section 3(a) to export US natural gas by pipeline to Canada for subsequent liquefaction and export (i.e., re-export) to non-FTA nations.

The Bear Head LNG proceedings presented legal issues of first impression and "an unusual factual circumstance," as DOE/FE described it. DOE/FE's legal determinations in the Bear Head LNG proceedings were significant. But the legal significance of the Bear Head LNG orders is dwarfed by the political implications of DOE/FE's announced poli-

NATURAL GAS PIPELINES

FIG. 1



Source: US Energy Information Administration

cies of adopting a laissez-faire approach to applications for Canadian gas in-transit through the US and giving the green light to natural gas exports of US natural gas to Canada for liquefaction and export to non-FTA nations.

NGA Section 3 provides only two legal standards for authorizing exports of US natural gas and LNG. Section 3(a) involves a lengthy public interest analysis for exports to non-FTA nations, while Section 3(c) provides an expedited process whereby exports to FTA nations are granted without modification or delay. Before DOE/FE's Feb. 5 orders, it was unclear which of these standards the agency would apply to applications proposing exports of US-sourced gas to an FTA nation for liquefaction and subsequent re-export as LNG to a non-FTA nation.

To complicate matters, DOE/FE previously provided little guidance or procedural transparency regarding how it would review Canadian applications. The DOE/FE's Procedures for LNG Export Decisions apply only to non-FTA exports from the Lower-48 states and do not address exports from Canada.[4] Similarly, DOE/FE had not considered Canadian LNG exports in its recently issued studies examining the cumulative impacts of LNG exports to non-FTA nations in 12-20 bcfd volumes.[5]

In reviewing Bear Head LNG's in-transit and non-FTA applications, DOE/FE had to determine which of the two legal standards under NGA Section 3 applied. The department opted to apply the discretionary, non-FTA standard, LNG produced at the Bear Head LNG being intended for delivery and end-use in non-FTA nations. It explained that its decision was rooted in Congressional intent that all exports destined for non-FTA nations be reviewed for their consistency with the US public interest. To do otherwise, DOE/FE reasoned, would permit potential exporters to evade the non-FTA public interest analysis simply by transiting natural gas and LNG through an FTA nation.

In anticipation of this approach, Bear Head LNG had included a public interest analysis in support of its proposed LNG exports from Canada to non-FTA nations, although it expressly caveated that "nothing in [its] Application is intended as a concession…that NGA Section 3 jurisdiction extends to LNG exports from Canada."[6]

Bear Head LNG's proceedings required DOE/FE discharge its statutory mandate under the NGA without violating US obligations under the North American Free

Trade Agreement (NAFTA) or aggravating a US-Canada energy relationship already strained by discord over the Keystone XL pipeline.[7]

DOE/FE's decision to exercise its NGA Section 3(a) jurisdiction extends beyond the US-Canada border (where the export of US natural gas by pipeline will occur) and follows the gas into Canada (where the export of LNG by vessel will occur). Accordingly, the non-FTA order arguably is an exercise of extraterritorial jurisdiction by DOE/FE, which is not to say it is impermissible.

To further complicate matters, before DOE/FE'S issuance of the in-transit order, there was uncertainty regarding which NGA Section 3 standard DOE/FE would apply to in-transit shipments of Canadian gas and whether DOE/FE would be legally consistent in exercising its NGA Section 3 jurisdiction when Canadian gas was in question, as opposed to US gas.[8] DOE/FE opted to dismiss the in-transit application for lack of jurisdiction. Canada's National Energy Board (NEB) also had authorized, without restriction, the export of Canadian gas intended for liquefaction and export from US West Coast projects, including Jordan Cove.[9]

With the lawsuits stemming from the US decision to reject the Keystone XL as a backdrop, and a newly elected Canadian government looking for a fresh start with the Obama Administration, particularly in energy and climate change, DOE/FE's favorable determinations in the Bear Head LNG proceedings strengthened ties between the two nations.

NEPA

A secondary but significant legal issue arose under the National Environmental Policy Act (NEPA), which requires DOE/FE to consider the environmental impacts of its decisions on applications seeking authorization to export natural gas. In the past, DOE/FE could meet its NEPA obligations as a cooperating agency in the NEPA review process led by FERC for US LNG terminals and plants. In the case of the Bear Head LNG project, however, the environmental and safety review would be conducted by Canadian federal, provincial, and local authorities.

When Bear Head LNG filed its applications, relevant DOE/FE non-FTA precedent could be summarized in a single bullet:

- In applications involving the construction of new, or the modification of existing, LNG facilities subject to FERC jurisdiction, DOE/FE acts as cooperating agency in the NEPA review process led by FERC. DOE/FE then adopts the NEPA documentation prepared by FERC, be it an environmental assessment (EA) or environmental impact statement (EIS), provided DOE/FE has conducted an independent review of such NEPA documentation and determined its comments and suggestions have been satisfied. In those instances that an EA is prepared, DOE/FE issues a finding of no significant impact (FONSI). In other instances that an EIS is prepared, DOE/FE issues a record of decision.

Since then, relevant DOE/FE non-FTA precedent has evolved, culminating with the Feb. 5, 2016, decisions:

- In applications involving existing LNG facilities not subject to FERC jurisdiction, DOE/FE grants categorical exclusion under its regulations at 10 CFR Part 1021, Subpart D, Appendix 85.
- In applications involving the construction of new CNG facilities not subject to FERC jurisdiction, DOE conducts the NEPA review process and prepares NEPA documentation.
- In applications involving the construction of new LNG facilities in Canada (i.e., not subject to FERC jurisdiction), DOE/FE grants categorical exclusion in accordance with its regulations at 10 CFR Part 1021, Subpart D, Appendix 85, with authorized export volume in proportion with the level of existing US pipeline capacity.

In-transit shipments

DOE/FE dismissed Bear Head LNG's in-transit application on the grounds that in-transit shipments returning to the country of origin are not imports or exports within the meaning of NGA Section 3, such that they fall outside of DOE/FE's NGA Section 3 jurisdiction. In reaching this conclusion, DOE/FE noted Congress' likely intention that the terms import and export apply only to those categories of shipments that, by their nature, could have a material effect on the US public interest. Shipments of Canadian-sourced natural gas between Canadian points, according to DOE/FE, are "categorically unlikely" to have a material impact on the US public interest and therefore lie outside DOE/FE's NGA Section 3 purview.

In further support of its jurisdictional determination, DOE/FE cited a 1977 agreement—the Agreement Between the Government of the United States of America and the Government of Canada Concerning Transit Pipelines—which espouses a laissez-faire policy for in-transit shipments of hydrocarbons between the two countries.

Despite dismissing the application and disclaiming Section 3 jurisdiction, however, DOE/FE drew on its authority under Section 16 of the NGA to direct Bear Head LNG to file monthly reports and maintain records related to in-transit shipments.

Jordan Cove

In its Mar. 11 Jordon Cove order, FERC considered both Jordan Cove's application under NGA Section 3 for the terminal, and Pacific Connector's application under NGA Section 7 for the pipeline. FERC first evaluated and rejected the proposed pipeline, finding that Pacific Connector was unable to adequately demonstrate a market need. FERC next denied Jordan Cove's Section 3 application on the grounds that, without a supply source, the terminal could

APPROVED LNG IMPORT-EXPORT SITES[1]

FIG. 2

Import terminals

US

Approved, under construction; FERC

1. Corpus Christi, Tex.: 0.4 bcfd; Cheniere-Corpus Christi LNG

Approved, not under construction; FERC

2. Salinas, PR: 0.6 bcfd; Aguirre Offshore GasPort LLC

Approved, not under construction; MARAD/Coast Guard

3. Gulf of Mexico: 1.0 bcfd; Main Pass McMoRan
4. Gulf of Mexico: 1.4 bcfd; TORP Technology-Bienville LNG

Export plants

US

Approved, under construction; FERC

5. Sabine Pass, La.: 2.76 bcfd; Cheniere-Sabine Pass LNG
6. Hackberry, La.: 1.7 bcfd; Sempra-Cameron LNG
7. Freeport, Tex.: 1.8 bcfd; Freeport LNG Development-Expansion-Liquefaction
8. Cove Point, Md.: 0.82 bcfd; Dominion-Cove Point LNG
9. Corpus Christi, Tex.: 2.14 bcfd; Cheniere-Corpus Christi LNG
10. Sabine Pass, La.: 1.4 bcfd; Sabine Pass Liquefaction[2]

Approved, not under construction; FERC

11. Lake Charles, La.: 2.2 bcfd; Southern Union-Lake Charles LNG

Canada

Approved, not under construction

12. Port Hawkesbury, NS: 0.5 bcfd; Bear Head LNG
13. Kitimat, BC: 3.23 bcfd; LNG Canada
14. Squamish, BC: 0.29 bcfd; Woodfibre LNG Ltd.

[1]As of Mar. 22, 2016. [2]Trains 5 and 6, Train 5 under construction
Source: US Federal Energy Regulatory Commission

provide no benefit to the public that would justify the impacts of building it.

FERC's order marked the first denial of an LNG export project in the Lower-48 states. But as discussed in the Jordan Cove order, FERC's rationale for denying the Pacific Connector pipeline is not without precedent. Any applicant who has not entered into binding precedent agreements for a significant portion of a proposed pipeline's capacity and is faced with significant landowner opposition will be challenged to satisfy FERC's public convenience and necessity requirement.

In looking at stand-alone interstate pipelines (pipelines not proposed to directly interconnect with LNG terminals and that do not cross the US border into Canada or Mexico), FERC typically has no basis for considering the public interest served by the import-export of natural gas or LNG in its consideration of public convenience and necessity under NGA Section 7. FERC also "has not previously found a proposed pipeline to be required by the public convenience and necessity under NGA Section 7 on the basis of a DOE finding under NGA section 3 that the importation or exportation of the commodity natural gas…is consistent with the public interest."[9]

FERC, however, had never before predicated approval of an LNG export plant on the associated pipeline's ability to satisfy the public convenience and necessity requirement under NGA Section 7. In fact, in most (if not all) orders considering both LNG terminals or plants and interstate pipelines, FERC has first considered the LNG terminal (which benefits from the Section 3 presumption in favor of approval) and then the pipeline, which under Section 7, does not benefit from a presumption in favor of approval.

In the Jordan Cove order, however, FERC reversed that sequencing and first considered the pipeline, followed by

the export plant. FERC therefore never reached a favorable public interest determination on the plant. Without this favorable determination, the possibility of relying on generalized market conditions supporting the export of LNG to substantiate, even in part, the need for the pipeline, was removed. The stage then set for FERC to consider the Pacific Connector pipeline on a stand-alone basis under the more exacting Section 7 standard failed to meet the requirements needed for approval, its reliance on generalized market demand deemed insufficient to counterbalance landowner opposition.

The authors express no opinion with regard to the likelihood of a different outcome for the Jordan Cove project had FERC followed the same approach taken in other LNG proceedings and allowed Pacific Connector to enjoy the cushioning a favorable public interest determination on the plant may have provided. But it is clear that FERC's discretionary authority may be exercised without advance warning.

Section 7(c) of the NGA requires companies seeking to build and operate an interstate pipeline to apply to FERC for a certificate of public convenience and necessity.[10] In determining whether an application meets this standard, FERC balances the benefits of the project against potentially adverse effects on economic interests.

To satisfy the "necessity" aspect of the Section 7 standard, an applicant must demonstrate a market need for a pipeline's services. Applicants can do this in a variety of ways, such as submitting precedent agreements, demand projections, potential cost savings to consumers, or a comparison of projected demand with the amount of capacity currently serving the market. Although FERC considers all of the information provided by an applicant, precedent agreements constitute "significant evidence of need or demand for a project."[9]

Indications of market need are then weighed against a project's potentially adverse economic impacts. FERC assesses whether the applicant can financially support the project without relying on subsidization from existing customers, and whether there is an adverse impact on the interests of the applicant's existing customers, competitors and their captive customers, and landowners and surrounding communities.[9]

Here, according to FERC, is where Pacific Connector failed to adequately demonstrate evidence of market need for the proposed pipeline.

The application also faced opposition from landowners, who identified several possibly detrimental impacts on their economic interests, such as land valuation, tax revenue, and business operations. Because Pacific Connector had acquired only a small portion of the easements required to develop the project, FERC noted that some rights of way would have to be obtained by eminent domain. FERC denied the application, finding that the "generalized allegations of need proffered by Pacific Connector do not outweigh the potential for adverse impact on landowners and communities."

Having denied Pacific Connector's application to construct and operate its proposed interstate pipeline, FERC then rejected the Jordan Cove plant's Section 3 application. FERC noted that the Pacific Connector pipeline was the only proposed transportation path for natural gas to reach the Jordan Cove LNG plant and that it could not operate absent the pipeline. Asserting that it "has not previously authorized LNG export terminal facilities without a known transportation source of natural gas," FERC concluded that permitting Jordan Cove to site, construct, and operate the LNG terminal would be inconsistent with the public interest. FERC made this decision, notwithstanding that DOE/FE already made a favorable public interest determination with regards to Jordan Cove's plant.[11]

On Apr. 8, 2016, Jordan Cove and Pacific Connector filed a request for rehearing of the Mar. 11 order, asking FERC either grant the application or permit Jordan Cove and Pacific Connector to supplement their public convenience and necessity findings. Specifically, Jordan Cove and Pacific Connector requested FERC to grant rehearing and grant their Section 3 and Section 7 applications. Alternatively, they requested FERC grant rehearing and (1) grant the applications, subject to a condition that would prevent the initiation of condemnation proceedings until executed precedent agreements are submitted to commission staff; or (2) stay the Mar. 11 order and re-open the record for 6-months to receive additional evidence of customer support. On May 9, FERC issued on order granting rehearing of the Mar. 11 order and extending the time by which FERC must act on the request for rehearing. OGJ

SPECIAL REPORT

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LNG oversupply faces slowing Asian demand

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Prolonged LNG oversupply in the face of slowing Asian demand will be the biggest factor affecting the industry in 2016. Continuing low oil prices will also affect the LNG industry in expected ways (delays and cancellations in export projects) and unexpected ways (takeovers between major players in an already consolidated industry). How the industry reacts to the oversupplied, low-price environment will have far-reaching consequences.

Only a handful of export projects made a final investment decision (FID) in 2015. These include one land-based greenfield project (Cheniere Energy's Corpus Christi LNG), one floating project (Golar's Cameroon project), and two relating to existing LNG export projects (Cheniere's Train 5 expansion at Sabine Pass, La., and Woodside's North West Shelf Greater Western Flank Phase 2 upstream gas development project in Australia). Petronas's Pacific Northwest LNG made a conditional FID in mid-2015, dependent on obtaining certain Canadian governmental approvals, the most important of which is a federal environmental approval that was recently postponed.[1]

Projects cancelled in 2015 included Downeast LNG in the US and Shell's Arrow LNG in Australia. Two Canadian projects were halted in first-quarter 2016—AltaGas Ltd.'s Douglas Channel LNG and Repsol's Canaport LNG—as was Woodside's Browse LNG in Australia and Colombia's Pacific Rubiales project. The cutback in capital spending has also resulted in FID delays for projects such as Inpex's LNG plant in Indonesia and Petronas's second floating LNG project in Malaysia. Project postponement, whether officially announced or not, may be tantamount to cancellation in at least some of these cases.

A number of projects still aim to make an FID and start construction in 2016, including Anadarko's Mozambique LNG, Eni's Coral LNG offshore Mozambique, Kinder Morgan's Elba Island LNG, Liquefied Natural Gas Ltd.'s Magnolia LNG, and BG Group-Energy Transfer Partners' Lake Charles LNG. The key to successful development of these projects will be their ability to attract customers to support financing. This need for buyers is one reason small to mid-scale plans may lead the next wave of export projects; they have less production to sell and lower costs to finance.

Project developers may be forced to assume that postponing FID to beyond 2016 is inevitable and turn their attention instead to increasing their projects' competiveness and ensuring sufficient development funding remains available.

Some 104.8 million tonnes/year (tpy) of liquefaction capacity is expected to come online by 2020 as a result of completing at least 10 greenfield projects (Table 1). These projects will add to the three export projects that started production in 2015—Santos's Gladstone LNG (7.8 million tpy) in Australia, ConocoPhillips's Australia Pacific LNG (9 million tpy), and Mitsubishi's Donggi-Senoro in Indonesia (2 million tpy)—plus Sabine Pass (eventually 18 million tpy) and Chevron's Gorgon LNG (eventually 15.6 million tpy) in Australia, both of which started first-train production in first-quarter 2016.

This new capacity has led some to predict a prolonged LNG oversupply. Buyer-friendly terms are arising in LNG sale and purchase contracts as a result, including greater volume and destination-flexibility and more seasonality in deliveries.[2]

India's Petronet also shook up the market by opting to buy spot LNG cargoes instead of honoring its contract to purchase LNG from Qatar's RasGas, taking less than its required cargoes under the RasGas contract.[3] RasGas and Petronet have since negotiated a new contract price at a 50% discount, with RasGas reportedly waiving recovery of $1 billion otherwise due from Petronet as part of the agreement.[4] Following Petronet's success, China National Petroleum Corp. (CNPC) announced it also intends to renegotiate its LNG price with Qatar.[5]

Other buyers have publicly stated their intention to use flexibility in existing contracts to resell cargoes in the spot market or simply procure more supplies in the spot market than under long-term contracts. If other buyers follow suit,

this development could affect financing for new LNG export projects, as lenders place more scrutiny on the risk of buyers not honoring the terms of long-term, take-or-pay contracts. Even where buyers simply use their contractual flexibility to divert cargoes into the spot market, such actions could mean more competition for producer-sellers looking to place excess cargoes.

LNG EXPORT PROJECTS UNDER CONSTRUCTION Table 1

Project	Location	Expected startup	Capacity, million tpy
Sabine Pass, Trains 3-4	Louisiana	2016-17	9.0
Gorgon, Train 1 started	Australia	2016-17	10.4
Petronas FLNG 1, floating	Malaysia	2016	1.2
Prelude, floating	Australia	2017	3.6
Golar Hilli, floating	Cameroon	2017	1.2
Wheatstone LNG	Australia	2017	8.9
Ichthys LNG	Australia	2017	8.9
Exmar. floating	Cameroon	2017	1.2
Freeport LNG	Texas	2018	13.9
Yamal LNG	Russia	2018-21	16.5
Cameron LNG	Louisiana	2018	12.0
Cove Point	Maryland	2018	5.2
Corpus Christi LNG	Texas	2019	13.5
Total			**104.8**

Large FLNG

When Shell launched the Prelude LNG project off Australia, it was heralded as the beginning of a new era for floating liquefaction technology. Such exuberance has been dampened by more recent events, from Browse LNG's (in which Shell has a 27% participating share) cancellation to shipping company Hoegh LNG's exit from the floating liquefaction business. The Indonesian government also recently rejected Inpex's floating liquefaction proposal for the Masela Abadi project on its belief that an onshore solution offers more economic benefit to the country.[6]

When Shell made its FID on Prelude LNG, however, oil was trading near $120/bbl[7] and it was the sole owner and developer of the project and made its decision on the basis of equity financing. The more recent announcements similarly reflect the economic circumstances in which they occurred, with current oil prices also cited in Petronas's delay of its second floating liquefaction project.[8]

While large floating liquefaction projects have been touted as cheaper, faster to construct, and more effective for certain locations, whether a large floating liquefaction project is successful ultimately depends on the same factors as a land-based project. Overcoming these factors, including permitting, attracting buyers, and procuring financing, is more challenging for all LNG export projects in the current climate of high oil prices and plentiful LNG supplies.

Business impacts

Even though most US LNG export projects aren't yet running, early movers into the industry have sold or want to sell-down committed liquefaction service capacities or LNG volumes. Lowered domestic demand prompted GAIL (India) Ltd. to offload some of its Cove Point capacity and Sabine Pass volumes.[9] Pertamina also sold Total 0.4 million tpy of its contracted volumes from Corpus Christi LNG starting in 2020 in exchange for Total supplying it 0.4-1 million tpy from its global portfolio.

LNG oversupply has likewise led to a drop in LNG shipping prices. At the end of 2015 charter rates were $32,000/day, 50% lower than the previous year.[10]

Available capacity in the secondary market could, however, lead to a lower cost of entry into an industry traditionally dominated by a handful of players. Some shippers of other commodities are already pushing into the LNG industry, helping fuel the rapid expansion of the LNG spot market. Non-traditional LNG players such as Glencore, Vitol, and Trafigura all recently began or expanded LNG trade,[11] with Trafigura doubling its LNG trading volumes in just 1 year.[12] Market veteran Total is aiming to double its LNG trading volumes by 2020.[13]

Along with the portfolio players, traditional LNG buyers are seeking opportunities to participate in spot LNG trade. These developments could lead to exponential growth in the LNG spot market.

Mergers, acquisitions

The recent merger between Shell and BG combined 33 million tpy of LNG production in one company.[14] Woodside's bid to take over Oil Search (whose assets include a stake in Papua New Guinea LNG) was rejected and ended in December when Woodside withdrew its proposal.[15] Other LNG companies (such as Santos and Excelerate) targeted for takeover have generally rebuked such efforts. Market observers viewed Woodside's refusal to increase its offer price for Oil Search as an indication that oil prices have not yet bottomed.

Companies have also shown more interest in strategic divestments of certain assets, especially minority stakes in LNG projects, to raise capital and reduce debt. Activist shareholders drove Apache to sell its stakes in the Wheatstone and Kitimat LNG projects.[16] And while Santos rejected a takeover offer, it did sell an 11.7% stake in the company to Chinese LNG newcomer ENN Energy Holdings Ltd. As part of merging with BG, Shell sold off its stake in Kinder Morgan's Elba Island project while retaining its right to LNG capacity there. Shell is now considering a divestiture of its North Sea oil assets.[17]

Other companies, however, see the potential to increase their LNG-related stakes in the midst of the current downturn. TransCanada recently announced its $13 billion acquisition of Columbia Pipeline Group, which will help position it "to transport North America's abundant natural gas supply to liquefied natural gas terminals for export to international

NEW FSRU FLEET ASSIGNMENTS 2015

Table 2

Vessel	Storage, cu m	Owner	Charterer	Initial charter, years	Location
Explorer	151,000	Excelerate Energy	Dubai Supply Authority	10	Dubai, UAE
Exquisite	150,900	Excelerate Energy	Engro Corp.	—	Karachi, Pakistan
Golar Eskimo	160,000	Golar LNG	Jordan LNG	10	Port Aqaba, Jordan
Golar Igloo	170,000	Golar LNG	Kuwait National Petroleum Co.	5	Mina al-Ahmadi, Kuwait
Höegh Gallant	170,000	Höegh LNG	Egyptian Natural Gas Holding Co. (EGAS)	5	Ain Sokhna, Egypt
BW Singapore	170,000	BW Maritime	EGAS	5	Ain Sokhna Port, Egypt

markets."[18] To fund the acquisition it will sell its merchant power assets in the Northeast US.[19] ExxonMobil is rumored to be pursuing a stake in Eni's Mozambique project.[20]

LNG buyers, meanwhile, have increased collaboration. The major example completed in 2015 is the fuel-procurement venture Jera, between Tokyo Electric Power Co. and Chubu Electric Power Co. Inc., which created the largest LNG buyer in the world, with about 40 million tpy of annual demand.[21] Jera has entered into LNG collaboration MOUs with Singapore's Pavilion Gas, the Electricity Generating Authority of Thailand, GAIL, South Korea's Kogas, and China National Offshore Oil Corp. and CNPC. Tokyo Gas has entered into similar MOUs with Taiwan's CPC Corp. and fellow Japanese utility Tohoku Electric. These collaborations are, in part, aimed at further increasing buyers' leverage in LNG negotiations.

Major buyers additionally are seeking the right to divert or resell cargoes without obtaining the seller's approval. Pricing index variations emerged in 2015 seeking shorter contract terms and supply flexibility based on seasonality. Cheniere Marketing has taken the lead in exploring new pricing indices, inking sales contracts based on European gas indices. Tokyo Gas called for pricing index diversification in its efforts to procure another 2-3 million tpy for 2020.[22]

Tokyo Gas has also noted its preference for 5-10 year terms.[22] Jera similarly said that it will be relying more on short and mid-term contracts to fulfill its LNG demand, notwithstanding that such terms may not be adequate for LNG export projects' financing requirements.

The degree of seasonality extracted by PetroChina from Qatar may end up being a major concession. Seasonality is desirable for LNG buyers who have historically looked to spot cargoes in managing seasonal demand fluctuations. But seasonal deliveries are hard to manage for LNG export projects that have to sell and perhaps transport full production throughout the year. While Qatar's arrangement with PetroChina is limited to 2016, Qatar has left open the possibility of extending the arrangement.

LNG shippers, meanwhile, are joining forces to improve cost efficiencies. Golar LNG, Dynagas, and GasLog Ltd. announced an agreement whereby they will contribute certain LNG ships to a pool available to the spot market. Sinotrans has also announced five joint ventures with Dynagas and China LNG Shipping to provide LNG ships for the Yamal LNG project.[23] Industry analysts are predicting more joint ventures and mergers in 2016 as the LNG shipping industry deals with a low charter-rate environment.

New demand

Traditional Asian LNG buyers have cut their forecast demand. Assuming the successful restart of numerous nuclear reactors, Japan predicts its LNG demand will decline to a 5-year low of 79.6 million tpy starting in 2016.[24] Korea, the second largest LNG importing country in the world after Japan, also expects its LNG demand to fall.[25]

China and India dominate the list of import terminals under construction and the Middle East the list of floating import terminals placed into service this year. New LNG importers Egypt, Pakistan, and Jordan bought a total of 5.5 million tonnes of LNG in 2015.[26] According to the International Energy Agency (IEA), China and the Middle East will be the big centers of overall gas demand by 2035.[27]

Some additional demand should be created by the six additional floating storage and regasification units (FSRU) delivered or contracted in 2015 (Table 2).LNG import projects under development suggest that the next wave of LNG buyers will be smaller and new. The main problem such buyers pose for exporters is access to sufficient credit.

Production shutdowns

Producers shut down almost 25 million tpy of LNG production in 2015 at four export terminals. Egypt's gas shortage continues to hinder operations at both the Idku (7.2 million tpy) and Damietta (5.5 million tpy) export terminals. BG has declared force majeure at the Idku terminal and the owners of the Damietta LNG plant (Union Fenosa and Eni) are pursing arbitration against the Egyptian Government to restart gas supplies and LNG production. While there have been two recent major gas discoveries offshore Egypt and BG has agreed to buy Noble's stake in the Aphrodite field off Cyprus, intending in part to supply the Idku terminal,[28] these measures are unlikely to permit Egypt to restart LNG exports in the near term. Egypt is now an emerging LNG buyer, procuring two floating regasification units to import LNG and seeking a third for delivery within 2 years.[29]

Angola LNG (5.2 million tpy), which was shut down in 2014 for a major rebuild, has yet to restart. Chevron had

hoped for a restart by end-2015 but is now targeting July of this year.[30] Upon restart, the industry will keep a close eye on its reliability.

Yemen LNG (6.7 million tpy) has been shut since April 2015 due to civil unrest by Houthi rebels.[31] There are no signs production will resume soon.

Other export plants have also suffered unforeseen curtailments. In late December force majeure was declared at Nigeria LNG due to "acts of sabotage" on a pipeline to the terminal.[32] The force majeure may affect deliveries to long-term buyers in Italy, Spain, Turkey, Portugal, and France.[32]

Project costs

One potential bright spot from the downturn in oil prices might be decreased construction and development costs. While this did not occur in 2015, the completion of three projects this year and increased contractor competition resulting from the scarcity of new export project FIDs, may yet help reduce overall project costs.

Labor costs, however, are region-specific and will vary. North America labor costs remain below historical average[33] and Woodfibre LNG is one project that believes it can take advantage of lowered labor costs to cut construction costs.[34]

LNG export projects may also look to new project designs or technology to lower costs. Magnolia LNG credits its proprietary optimized single-mixed refrigerant (OSMR) technology for its $500/tonne of capacity construction cost vs. an average of $800-900/tonne for other US projects.[35] The costs at Lake Charles LNG are an estimated $512/tonne, which could yield a liquefaction toll cost of less than $2.00/MMbtu and a delivered price of $6.50/MMbtu into Asia.[36] Fortuna LNG in Equatorial Guinea has reportedly cut capital costs from $800/tonne to $600/tonne and secured an HOA with a customer willing to prepay for LNG in its initial stages of production.[37]

The lowered cost and shortened development time for floating LNG regasification units (FLRUs) have facilitated smaller LNG users' entrance to the industry. In the western hemisphere, FLRUs are planned for Hawaii, Puerto Rico, and Jamaica. Cheniere appears to be preparing for the increase in demand for small-scale LNG, requesting government approval to permit its Sabine Pass terminal to load LNG into LNG-fueled vessels and handle containerized LNG.[38] AES Dominicana is seeking to capitalize on its existing onshore LNG terminal in the Dominican Republic to provide LNG transshipment and bunkering services for the Caribbean and Latin American markets.[39]

Small-scale LNG's potential has also been recognized by Singapore's Pavilion Energy. Pavilion points to the fact that 65% of all contracts signed in the past 5 years are for less than 1 million tpy as a sign of the potential growth in small-volume business.[40] The company views the many small islands of Southeast Asia as a great fit for small-scale LNG solutions and is in talks with several parties regarding collaboration in this area. Gazprom and Fluxys have announced collaboration on developing a small-scale market in Europe.[41]

The growing use of FSRUs in LNG-to-power projects may provide a new source of LNG demand for liquefaction projects, potentially opening up new countries for LNG imports. AES Panama LNG, for example has been awarded the tender to build Panama's first gas-fired power plant and associated LNG import terminal.[42] LNG-to-power projects are also under development in Africa (including three in Ghana alone), Latin America, and Asia.

An LNG import capacity of 2-5 million tpy and higher exposes some of these projects to the same need for long-term offtake contracts or financing as LNG export projects. Activities in the Philippines (which is expected to import LNG given the depletion of its only major gas field) illustrate the problems facing these projects. While a few different parties are evaluating LNG-to-power projects there, progress has been delayed while long-term buyers, or partners to provide financing, are sought.[43] OGJ

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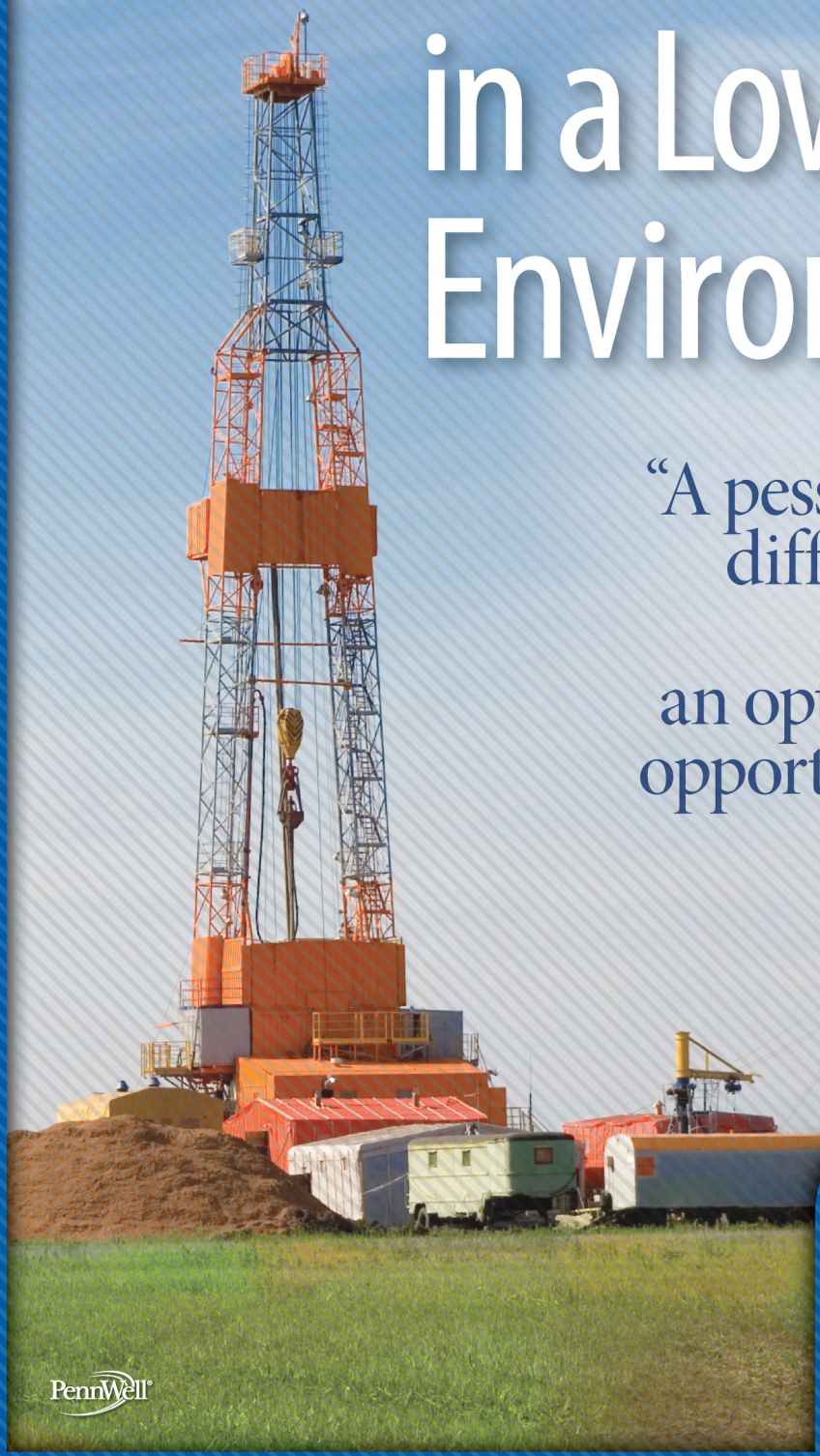
Business Strategies in a Low-Price Environment



"A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty."

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Recent low prices have challenged the industry. Technology remains an important element of success. Flotek remains committed to Research & Innovation in order to demonstrate their leadership in providing best-in-class, environmentally friendly, value-added technologies.

Low Price

What are companies doing?

There is good news and bad news for the oil patch. Prices are down dramatically; the predictable reactions are budget cuts and layoffs. With those announcements, drill rig counts have fallen and the negative feelings about jobs and the industry have grown. Suppliers, manufacturers, operators and companies of all sizes are making adjustments, and rightly so. But the industry does not make investments based on current prices; it makes them on expected prices, which are influenced by current ones. So, historical perspectives are in order. Figure 1 is a historical view of oil prices back to 1946.

Adjusting to 2015 dollars, the current prices ($35-$40) are still higher than the monthly averages for most of the past 70 years. There has been increased volatility in recent decades primarily due to OPEC's influence since the 1970's. Despite the volatility, the industry has been successful with the average prices over those years.

Natural production decline, on average 8%-10% per year, brings the need for more supply. The world still needs hydrocarbons. Although alternatives are gaining, most projections still show a large market share for hydrocarbons well into the future. The business reality is the price needs to be adequate to bring them to market. At current prices, companies must drive toward more efficiency and effectiveness to stay in business, and they are. Necessity is the mother of invention. Innovations, business process improvements, creative people and new technologies, all inspired by the current downturn, are helping the industry lower cost, be more efficient and profitable.

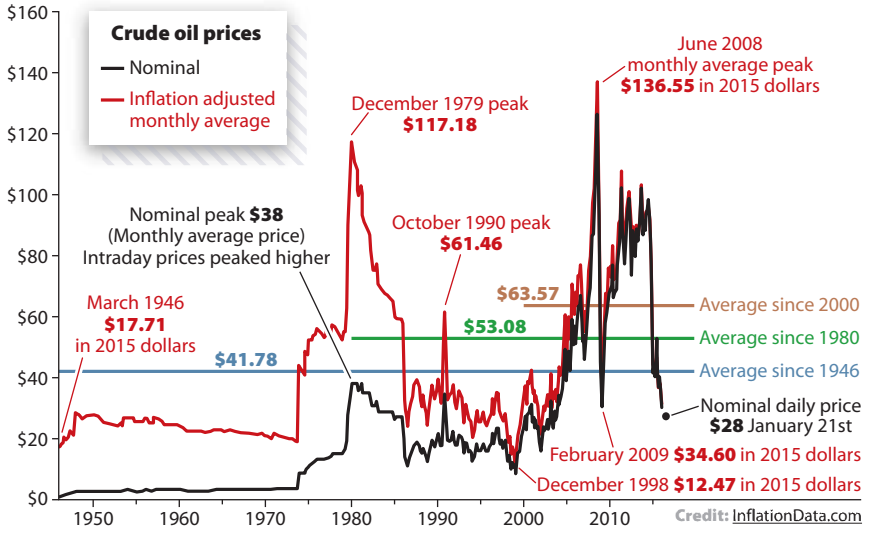
Survey results

PennEnergy Research conducted a survey of what the industry was actually doing to survive in this market. It confirmed cost reduction is important. Sixty-three percent (63%) of respondents thought cost reductions of 25% or less were achievable.

The tactics for attaining such cost reductions were most interesting. Efficiencies in operations ranked highest with forty-seven percent (47%) of respondents, the majority highlighting technology and innovation. Stopping or slowing certain activities was second with twenty-eight percent (28%). Re-negotiating with suppliers garnered fourteen percent (14%) and reducing work force, eleven percent (11%).

Sixty-five percent (65%) of respondents were operators or consultants advising them. The mix of respondents provides a good cross section of the industry. More than eighty-five percent (85%) of respondents described themselves as mid-level or higher, therefore, the information shared reflects opinions of many decision makers.

FIGURE 1



Low prices are a problem for the industry, but as Churchill reminds us, "...an optimist sees opportunity in every difficulty." Based on the survey, the opportunity is technology and innovation. The survey questions explored six facets of the industry's reaction which are summarized in Figure 2. First, we will examine the strategies companies are adopting to cope with the current price environment. The respondents were asked about four traditional business areas where improvement opportunities might exist: drilling, completions, production, and midstream (gathering, processing and transportation). In addition, the survey asked about data analytics, a relatively new business area. It is an active discussion topic, applicable to all facets of the industry.

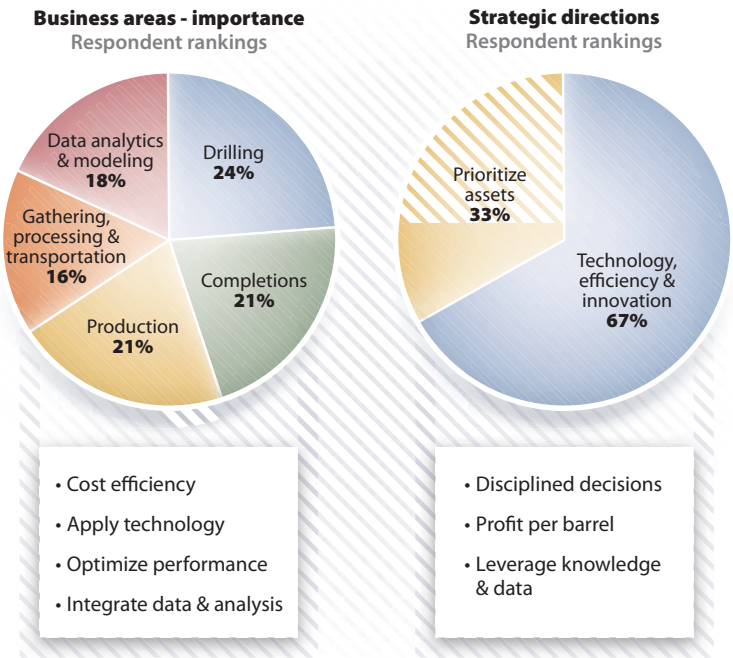
1. Strategies

Two strategic themes were chosen by respondents. Sixty-seven percent (67%) selected strategies that involved technology, innovation and finding ways to operate assets more efficiently and/or at lower cost. Thirty-three percent (33%) selected strategies that involved buying, selling and/or prioritizing assets. Despite the pricing challenges, companies recognize technology as a key to success. Continual progress is essential to remain viable in a competitive world.

Service companies know that technology is a driver for the business. John Chisholm, CEO of Flotek Industries, Inc. commented, "Technology innovation has always driven our industry. The ultra-tight rocks of unconventional reservoirs are still primarily produced with conventional reservoir practices. Technology to create hydrocarbon mobility in the nano-sized rock pores of shale is understood and becoming a best practice."

This bodes well for beleaguered shale operators. Getting more oil from a well lowers the cost per barrel produced. Despite the weak markets, Flotek believes technology is essential for the industry and is opening a new research and innovation center. It is uniquely designed for clients to interact with scientists and thought leaders directly.

FIGURE 2



Schlumberger, the largest of the service companies, is also aligned with the need for technology. More than twenty-five percent (25%)[1] of its 2017 total revenue is expected from new technologies. On February 3, 2016, as part of an earnings call outlining staff cuts and closing facilities, major service company, National Oilwell Varco CEO Clay Williams summarized the situation, "… the opportunity for NOV to once again pioneer new, more efficient ways of extracting oil and gas to reduce their cost."

Pioneer Natural Resources is pursuing an optimization strategy expedited by the low-price environment. Like others, margins have been squeezed. Pioneer is reducing wells drilled in 2016, yet increasing production. Over 2015, drilling cost per lateral foot declined ~30% while cumulative production per well increased ~50%. From investor presentations, the reason is "… completion optimization …"

Underlying Pioneer's optimization efforts are good assets and good financials (balance sheet and hedging position). However, the completion optimization program concerns the actual assets. The current price situation has resulted in less drilling activity, creating an opportunity for engineers and geologists to do what they do best; optimize performance. Pioneer's performance in 2016 is accomplishing that, more production and fewer wells.

Private equity-backed Silverback has been successful even in these tough times. They were rate-of-return driven even before the downturn; their private funding expects a rate of return (ROR). We "… cannot drill average wells; we must have best-in-class wells each time" says Stephen Lipari, Chief Operating Officer. Low prices only make the selection process more exacting. He noted the selection is not just the best of the opportunities, but is the best of the best opportunities when prices are low. Silverback achieves this by integrating data, involving decision makers and leveraging technologies.

A major operating company is following a strategy of knowledge efficiency sharing existing technologies among business units and searching for new ones ready for use in 2-3 years.

Another example is EOG Resources which is high-grading its Eagle Ford assets for premium drilling and completions locations. This process

is driven by efficiencies, technical advancements and geoscience breakthroughs. It identified over 3,200 premium drilling locations and more than 2 billion barrels of oil potential with superior returns.

At a strategic level, companies are using technology to survive and thrive in today's climate.

OBSERVATION—LAYOFFS AND GRADUATES

In the press, one of the biggest headlines is the reduction in force announcements. When asked how to achieve lower cost, staff reductions made up only 11% of the responses as a strategy and even less in the business areas.

Staff reduction pronouncements are a quick, visible way to demonstrate action to investors and near-term savings. Those who have lived through previous cycles understand there is long-term risk to losing experienced people. The survey may be showing that concern.

Responding to the energy boom, petroleum engineering schools expanded. Those students are now graduating into a very soft market. This survey identifies the need for technology and innovation. Youthful enthusiasm and unbiased thinking may well be good prescriptions for the innovation and technology demands of the current environment. The next few years will be challenging.

2. Drilling

Drilling is a critical business process identified by the highest number of respondents, twenty-four percent (24%), for potential improvement as a result of low prices. The top 3 from the survey were:

- Reduce non-productive time — 23% of respondents
- Drill multiple and longer sections into the pay zone from a single well bore — 23% of respondents
- Improved crews, better training — 13% of respondents

There are many companies supplying materials and equipment that impact these three areas. They all recognize the cost pressures the industry is under. One example is Georgia-Pacific Chemicals, which not only recognized the need for reductions, but took action to improve effectiveness and lower cost. They supply emulsifiers for drilling muds to carry cuttings and provide lubrication in well bores. Traditionally, emulsifiers are sold in liquid form. Georgia-Pacific Chemicals developed technology to produce a dry emulsifier which lowers transportation, handling, packaging and disposal cost. The net result is lower cost. In addition, because of the improved activity with the dry formulation, you can use only the amount of emulsifier required for the job.

The high ranking of "Improved crews, better training" recognizes this part of the business is about skilled people. Brigham Resources, a private operating company, noted the importance of well-trained, motivated crews. Drilling crews understand faster drilling allows the operator to be profitable and drill another well. Their efficiency can make their own jobs more secure. Despite low prices, Brigham is still drilling and crews recently completed a 21,000 foot well with a 10,000 foot horizontal section in 15 days. Such speed is possible with well-trained crews and dual telemetry Measurement While Drilling (MWD). Brigham recognized the accomplishments of the crews and hopes to have additional profitable wells as a result. Safety is not lost with speed because workers know incidents hurt efficiency and operators insist on, and often reward, safe performance.

3. Completions

Twenty-one percent (21%) of respondents identified completions as a business area for potential improvement. Three surfaced as the most important aspects to consider:

- Geologic understanding and better analysis of rock properties — 39% of respondents
- Better use of proppants and chemicals — 23% of respondents (survey included option to reduce use to save money which did not attract many respondents)
- Reduce time for a completion — 17% of respondents

Completions are a major expense and can directly affect the revenue generating (production) part of the business. It is critical to get them right, especially when margins are tight. Geology, proppants and chemicals were selected by sixty-two percent (62%) of respondents as areas for improvement in these challenging times.

Pioneer's completion optimization process includes adjusting lateral lengths, stage lengths, number of clusters per stage, fluids (volume and composition) and proppants (volume and composition). Much of Pioneer's success comes from application of existing technologies and their deep geologic and operational understanding of the basins. Optimization is an iterative process, and so far, adding more stages and more clusters, increasing the volume of water, and pumping more proppant have helped improve their well results. They are testing longer lateral lengths and different fluid compositions. There are many combinations of parameters to consider for the optimum mix with the various geological reservoir conditions. Pioneer's process has potential for more benefits as additional combinations of parameters and technologies are considered.

Silverback Exploration leverages completion fluids technology to reduce production risk on each

well. They have an analytical approach to optimize completions by selecting the most successful practices. An example is their selection of a robust fluid and proppant treatment, coupled with surfactant and solvent technology. This approach helps Silverback achieve better performance (i.e. more production) and meet their ROR objectives.

Flotek provides a perspective on the completions process which focuses on chemistry rather than mechanical aspects. It is about conditioning the reservoir to produce the hydrocarbons. The metric is simple and direct; more production. Unconventional reservoirs are unique in that pore structures in rocks are ultra-tight (often nano-scale) where capillary pressure dominates, resulting in primary depletion typically recovering only 8% to 10% of oil in place. Technology that can release some of that trapped oil is essential. Chemical surfactant and solvent technologies can enhance the mobility of all the fluids including injected water.

Both operating and service companies recognize the importance of completions to generate more production and better recovery from unconventional reservoirs.

4. Production

Production responses were varied, but focused on three areas:

- Technologies to increase recovery from a well including better understanding of reservoir data, re-stimulation and artificial lift — 50% of respondents
- Improve reliability and maintenance including better design of equipment, deferring workovers and maintenance — 24% of respondents
- Well site automation — 13% of respondents

Half of respondents were looking to improve recovery in the production phase, similar to completions. This comes not necessarily as a reduction in spending, but, as one operator said, comes by paying attention to cost and using technology to increase production/recovery thus lowering the cost per barrel.

There is an inventory of drilled and uncompleted wells and candidates for re-stimulation, all which may deliver profitable production even at lower prices. Technology for producing unconventional reservoirs is still very early in its lifecycle. Typical recovery in shale wells is less than ten percent of in-place hydrocarbons leaving opportunities for technology, analytics, and engineering innovation to increase recovery from the thousands of unconventional wells.

5. Gathering, processing and transportation

Gathering, processing, and transportation responses emphasized three areas of importance in these hard economic times. The top three were:

- Equipment and process efficiency including reliability of equipment, process efficiency and energy use — 61% of respondents
- Renegotiation of contracts for transportation — 25% of respondents
- Reductions in staff — 8% of respondents

Efficiency is the name of the game here since the entire system is on the surface and processes are well understood. Stochastic Simulation provides software which integrates reservoir and surface facility equipment. Their FlowAssure product optimizes the value chain from reservoir to market. As the industry is facing slimmer margins, tools like this are more and more important.

Transportation is often provided by a third party, so it is not surprising renegotiations of contracts were a common approach to cut costs. Those providers no doubt would also have equipment reliability and efficiency high on their priority list of ways to manage their business. They provide services to operators and understand they have cost pressures. Commercial and regulatory terms will be in play, but low prices will drive all value chain participants to be efficient.

This is the only area where staff reductions made the top 3 list, and even then only a single digit percentage.

6. Data Analytics

Data analytics was the last business area explored in the survey. There has been much industry discussion about the increasing volume and velocity of the data from many sensors (downhole and on the surface) and how it can be put to use. This data is far too often underutilized and the value missed. Eighteen percent (18%) of respondents felt data analytics offered ways to lower expenses or improve performance or both.

The data is spread across drilling, completions, production, and supply and transportation. Each discipline has the potential to improve its own performance. However, the concept of integration of data was raised by many as a way to improve understanding and achieve better business results.

Stochastic Simulation, Ltd, an Australian company, uses data you already have to optimize all the aspects of the business we have discussed. Getting more barrels from investments already made lowers the cost of a produced barrel, a very nice outcome in these lean times. In addition, their software uses geologic data to lower drilling nonproductive time. It also uses market and operational data to optimize gas production through the entire value chain. In times like these, companies like Stochastic Simulation help you get more from existing assets.

A major independent noted they cannot afford pilots and trials of unproven technology in these times. They have decided that using data from thousands of previously drilled wells can "teach them" best practices at a much lower cost. Taking

advantage of available data is not new. It has been an issue for several years. However, the price collapse has provided the additional motivation to apply data-driven approaches as low-cost ways to improve performance.

Stochastic Simulation, Brigham, Pioneer, Silverback, Flotek, Georgia-Pacific, and EOG all mention data and the ability to extract understanding as essential in these times. The importance is recognized across the value chain. This low-price market may finally motivate the industry to optimize value from existing data.

Conclusion

The oil and gas industry has seen low prices before. The physical and data analytic technologies available today provide new tools to reduce cost and increase hydrocarbon recovery. The choice of tactics seen in the survey and the company interviews show the innovative spirit is alive. Times are tough, but the industry is getting stronger. BG CEO Helge Lund said at Gastech on March 29, 2016, "As an industry, we face a big and challenging agenda. But this is an industry that is used to making the impossible, routine."

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COMPANY PROFILE

Better recovery — faster decisions

Stochastic Simulation

STOCHASTIC SIMULATION LTD
www.stochasticsimulation.com/

Drastic times require drastic measures. Innovation in digital information technologies is critical to achieve productivity gains which are essential when profitability is under pressure. The future winners in the oil and gas industry will be information masters.

Stochastic Simulation Ltd (Stochastic) is that innovation being adopted around the world by super majors, NOC's, operators, service companies, SME's and consultants.

Its modeling solutions are cloud hosted and internet delivered. The models produce uncertainty quantified information for reserves assurance, history matching, IAM production, drilling planning, etc.

The Stochastic Platform provides easy to use, fast and secure workflows and processes for modeling data you already have to optimize recovery of hydrocarbons. The Platform includes the following:

DrillAssure uses interpreted seismic to generate earth stress information prior to drilling. It significantly reduces drilling risk and cost. It also identifies reservoir compartmentalization due to fault sealing.

GasAssure is a steady state, fully compositional 'reservoir to market' integrated asset modeling tool. It is the only tool capable of integrating supply and demand seamlessly, delivering fast, accurate and reliable information for complex operational, development planning and marketing decision-making.

ResAssure is a revolution in reservoir simulation. It solves fully-implicit, dynamic 3-phase fluid flow equations for every geological realization in minutes versus weeks/months, faster than conventional reservoir simulators. In addition, it enables vastly faster workflows and improved productivity. It leads technical algorithmic modeling advancements in the industry with integration with GasAssure and DrillAssure.

FlowAssure combines GasAssure with thermodynamic pipeline, and oil and water modeling, including integration with third party engineering software. Steady state, three phase and compositional solutions enable rapid production forecasts with various sensitivities. The subsurface can be characterized as material balance tanks, scalable decline curves or a combination of both. FlowAssure integrates with ResAssure for numerical subsurface representation delivering the "holy grail" petroleum engineering tool.

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You may not expect to generate cost savings via chemicals, but Georgia-Pacific Chemicals can help you do just that.

Solution-driven Georgia-Pacific Chemicals for years has provided customers with robust high-performance emulsifiers for use in a variety of well types including: on-shore; off-shore; deep, high pressure and long horizontals. Using our decades of experience, we also have developed emulsifiers specifically to address the challenges of today's oil and gas marketplace by helping to control overall costs.

Savings

Although used in all wells, oil- and synthetic-based drilling fluids are the go-to drilling fluids for long horizontal runs and water-sensitive (shale) formations. The emulsifier is the active ingredient which enables the drilling fluid and the well bore to remain oil-wet. This drilling fluid provides a high level of lubrication to the drill bit for fast and formation-safe drilling.

So how can you save costs on such an integral system component? Georgia-Pacific Chemicals has at least **three ways to save**. Our inventive R&D staff can help match the right product to your requirements for effective use of your emulsifier budgets.

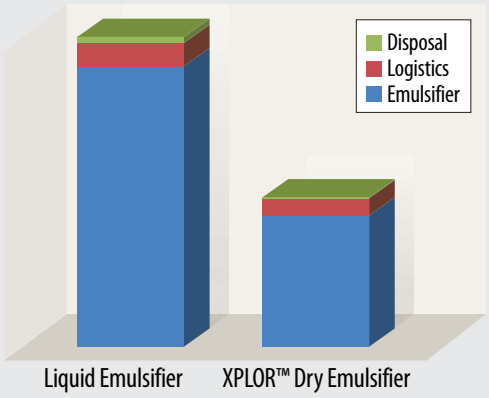
Use Dry Emulsifiers

1. Use less emulsifier. For example, instead of one-half drum (~216 lbs.) of traditional liquid emulsifier for mud treatment; you need only add 75 lbs. of XPLOR™ dry emulsifier.

XPLOR dry emulsifiers provide high performance in drilling muds with benefits that can positively affect operational efficiency and costs. Less emulsifier is required to treat a drilling fluid as a result of a 100% activity level and higher performance than traditional liquid emulsifiers. Compatible with diesel, mineral oil and synthetic solvents, XPLOR dry emulsifiers also reduce the need to purchase and store multiple types of emulsifiers.

2. Reduce transportation, drum disposal and handling costs by using bagged dry emulsifiers.

Shipped in 25 pound bags, XPLOR dry emulsifiers are easier to dose correctly; eliminate the need for hot boxing, jacketing or steaming in frigid conditions; and eliminate drum transportation, cleaning and disposal costs.



More than 50% savings in total cost

Use New Basic Emulsifiers

3. If you prefer an emulsifier in the traditional liquid form, pay only for the performance you need.

Why pay for features you don't need? While Georgia-Pacific Chemicals is known for its high-performance emulsifiers, there are conditions in which a simple, yet quality product will meet your requirement at the right value. These liquid basic emulsifiers are an economic alternative and are available in mineral oil- and diesel-based formulations.

Other Georgia-Pacific Chemicals Products

In addition to high performance and rudimentary liquid emulsifiers and dry emulsifiers, we offer fluid loss additives, rheology modifiers, corrosion inhibitors, and proppant coatings that impart enhanced crush resistance and can be used on a variety of substrates including sand, ceramic, and bauxite.

Research and Development

Our years of R&D experience result in a comprehensive understanding of the impact of additives on drilling fluid performance.

Our in-house testing capabilities include HPHT (High Pressure/High Temperature) and standard API filtration capabilities for oil- and water-based muds, variable temperature rheology testing and electrical stability. Our analytical capabilities include the ability to test, understand and quantify chemical structure; characterize physical and material properties as well as define macroscopic/microscopic product features.

Our scientists' expertise in chemistry derived from renewable sources and our sophisticated testing ability allows us to adapt, create and custom-formulate effective products for the oil and gas industry.

Start a dialog to see if an existing product will help you or if we can develop the product you need. The oil and gas industry has many challenges; Georgia-Pacific Chemicals stands ready to deliver solutions.

JUNE 2016 VOL 62; NO. 7

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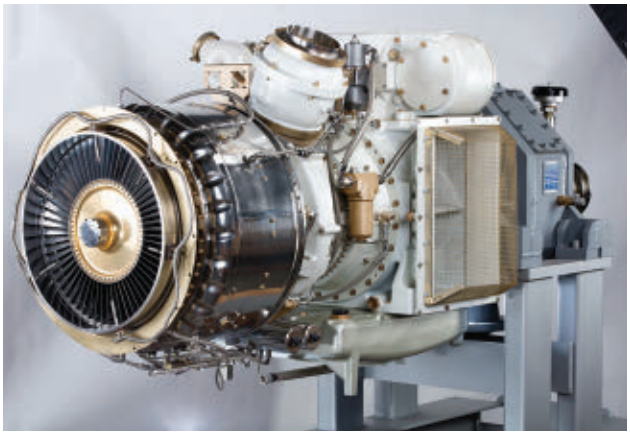
New military-proven gas turbine versions designed for fracing, portable electric power

A new version of military-proven **TF Series gas turbine** was announced at the Offshore Technology Conference for pump, compression, and portable power generation — including hydraulic fracturing.

TF50F is rated at over 5,000 hp and declared to "radically change the process of hydraulic fracturing, making it cleaner and more cost effective." Among important turbine design features: ability of the engine to operate on both gas and liquid fuel, and to change from one fuel to another while operating.

As a compact alternative to larger, heavier diesels — TF50F is a two shaft, free power turbine engine designed to accept high torque necessary for fracing. Complete TF50F details are free.



Vericor Power Systems: Alpharetta GA & Houston

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Latest frac pump series unveiled at OTC

Thunder Series frac pumps were unveiled at OTC to meet increasing pressures, 24/7 pumping duty cycles, and longer maintenance intervals.

Based on the GD-3000 pump platform, Thunder uses long stroke technology to operate at lower speeds as it enhances flow rate capabilities, declares the manufacturer. This feature is reported to extend pump maintenance overhaul life cycle as it also reduces consumables and associated labor costs by $250,000 over the life of the pump.

Thunder Series is designed to improve wear and tear resistance as it allows the power end maintenance overhaul to be consistent with engine, pump, and transmission service schedules. The pump's enhanced power end technology makes maintenance easy and safe to reduce downtime. The series also includes a triplex pump that reaches 2,550-BHP while a quintuplex reaches 3,000 BHP.

Gardner Denver: Houston

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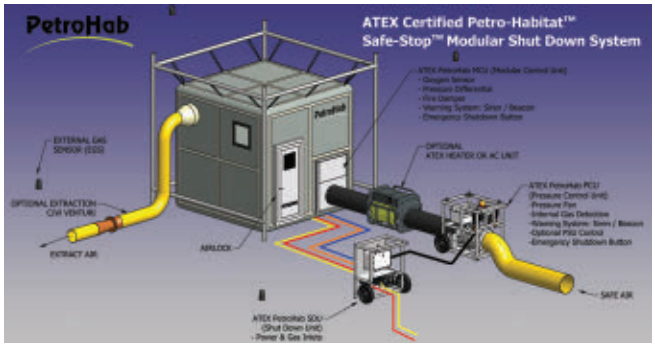

Hot work safety enclosure auto shutdown

ATEX-certified **Safe-Stop automatic shutdown system** for Petro-Habitat Hot Work Safety Enclosures was announced at OTC to "provide unrivalled safety whenever hot work is conducted in the vicinity of potential flammables, such as in ATEX Zone 1 rated hazardous areas as oil rigs and refineries."

It continuously monitors pressure inside the HWSE to create a "positive pressure environment," allowing hot work to be conducted inside the HWSE only if the air pressure within it exceeds the air pressure outside of it. Full specifics are free.

PetroHab: Dundee Scotland

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NEW PRODUCTS

Two-piece plunger reduces, eliminates shut-in times + maximizes production

First Responder two-piece plunger is announced to "optimize the highest flowing wells."

Benefitting from its manufacturer's 30+ years of Plunger Lift expertise, the new design reduces and even eliminates shut-in times while maximizing production. Plungers make more trips with faster fall times to deliver continuous fluid removal. They also often help wells achieve a significant increase in daily production, it's declared.

The product's name refers to the plunger's application, typically the first plunger used in a well's life cycle. Responder refers to the manufacturer's "unrivaled, responsive customer service." Additional First Responder specifics are yours free.

PCS Ferguson, Dover Artificial Lift: Frederick CO

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Drone-enabled services converge with the Industrial Internet of Things for many uses

All-inclusive, self-powered **DRONEBOX** is announced for deployment anywhere including remote areas where industrial assets, borders, or sensitive installation require constant monitoring.

It's designed as an "evolution over today's many unattended sensors and CCTV cameras," declares the manufacturer. It provides sensors freedom of movement using drones as their vehicles. You can deploy flying sensor systems to measure just about anything, anywhere, anytime, it's said. 24/7 reactivity provides critical information to operators — even those thousands of miles away.

Models ease scalability challenges for drone service operators in a broad range of applications including land surveys, infrastructure inspections, or construction site progress.

H3 Dynamics Group Pte. Ltd.: Singapore

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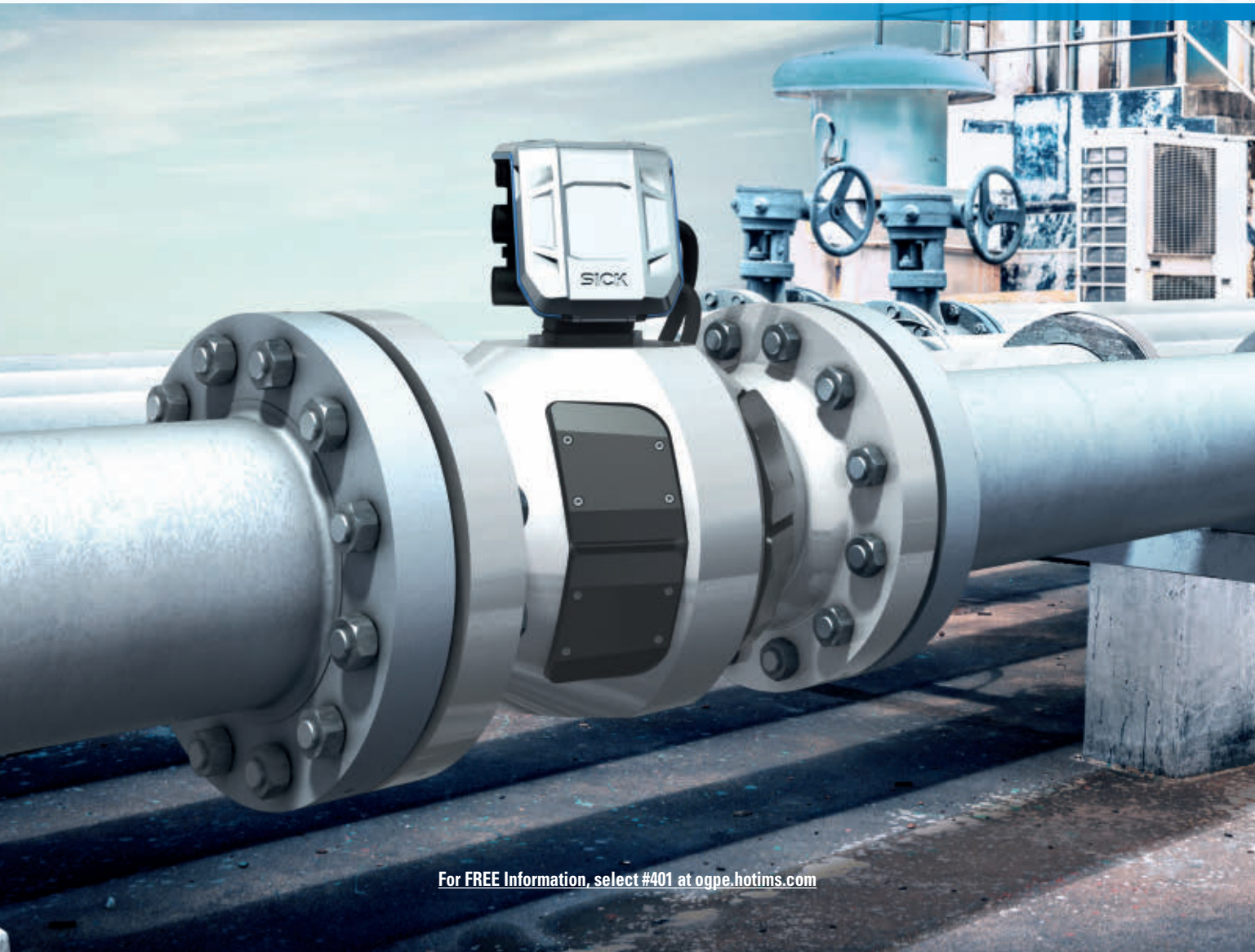

Valve, metering control improve chemical injection process

FluidCom chemical injection valves are newly invented to provide integrated flow control and metering via combined material and thermal effects.

The patented technology with development partners including Statoil Technology Invest and Aarbakke Innovation AS, is said to reduce both operator cost and capacity plus combine the function of multiple devices into one.

In field tests, FluidCom chemical injection valve and metering controller offered fully integrated logic controls for local or optional remote communication by wired or wireless HART.

Compared to existing valve installations, the configuration is also said to reduce on-site capacity relative to current valves that are larger in size and reliant on additional devices to perform the same function.

TechInvent AS: Stavanger

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Android device solves how can you use a Wall Reader — when there is no wall?

A new **Android device** is added to this software company's Mobile Access Control systems to help solve the common security problem "how can you use a Wall Reader — when there is no wall?"

It's designed to "provide technical innovation to the access control industry that is currently dominated by other Windows-based rugged hand held devices. This modern and discreet mobile device enables extended access control to be adopted by other sectors looking to enhance their security and safety offering in more urban areas. With increased security required by corporate companies in city dwellings, the devices let you verify access, see cardholder details, and integrate with leading access control systems.

SMI Global Ltd.: St Edmunds UK

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Pulsejet valves designed to reduce fugitive oil, natural gas pipeline emissions

Fast-acting, high-cycle **NexTech pulsejet valve with EcoPack stem packing** is introduced to reduce fugitive oil and natural gas emissions.

The new design comprises "a superior stem packing solution for high-cycle, fast-acting valves."

Models send a pulse of gas through a pipeline system. As a trunnion-mounted ball valve, NexTech accomplishes 90° or 180° rotation in speeds as low as 0.5 sec or faster. This actuation speed creates the gas 'pulse' through a pipeline system.

Pulsejets are designed to clean system filters, spray chemicals in an injection type system, or pulse debris/media through a pipeline to prevent clogging. They're engineered to cycle thousands of time each day. EcoPack stem packing handles abuse of fast cycle speed combined with high cycle count.

ValvTechnologies Incorporated: Houston

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Want to Stay Ahead of the IIoT Curve?

As an operations manager or engineer, one of your first challenges will be getting **all of your devices connected** to the internet.

Luckily, we've collected some great resources to guide you with this.

Here are some of the topics we cover:

- Calculating payback on your investment
- Addressing cyber security concerns
- Achieving device interoperability
- Connecting industrial devices to the internet

Learn more at

pages.moxa.com/IIoT

Moxa Inc. Tel: 1-888-669-2872 usa@moxa.com **www.moxa.com**

linkedin.com/company/moxa @moxainc youtube.com/moxavideo facebook.com/moxainc

MOXA
Reliable Networks ▲ Sincere Service

Oil & Gas Journal & OG&PE recently exhibited at and covered Society of Petroleum Engineers' **Offshore Technology Conference** in Houston.

Here are highlights representing over 3,500 **equipment manufacturer and service provider exhibitors** on which we gathered information. **To request free information or literature** on items of interest — simply go to **OGPE.com** — **Click "Product Info" (white typeface) at top.** Select by number or click the company name to visit their website. You can also click the items right here on the pages if you receive OG&PE digitally within the pages of Oil & Gas Journal.

Single string double-grip production packers

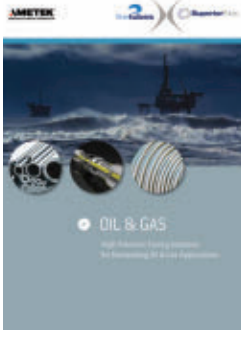
ASI-X single string double-grip production packers are mechanically set retrievable designs for use in any production application, it's announced.

Models are suited for treating, testing, or injection as well as in deep or shallow pumping or flowing wells. They can be left in tension or compression depending on well conditions. Standard ASI-X is designed for up to 7,000 psi differential pressure and comes in a high-temp 10,000 psi dp version.

D&L Oil Tools: Tulsa OK

For FREE Information, select #12 at ogpe.hotims.com

Precision oil & gas tubing solutions



High performance precision tubing for supercritical onshore and offshore oil and gas are described and illustrated in this free eight-page brochure.

An ever-expanding range of stainless steel, nickel, titanium, and zirconium alloy tubing are showcased for broad applications. These include downhole, hydraulic, and chemical injection control lines; subsea umbilical control lines; wellhead control panels; well monitoring; flowline control line tubing; and MWD/LWD tools pressure housing.

A full-page Supercritical Tubing Grade Chart is included.

Fine Tubes & Superior Tube, AMETEK Specialty Metal Products: Plymouth UK

For FREE Literature, select #250 at ogpe.hotims.com

ROAVs = oil / gas inspections and surveys

ROAVs: Remotely Operated Aerial Vehicles from this aerial inspection and surveying specialist highlight a free, illustrated 16-page brochure.

Since 2008 this company and its ROAVs have conducted close visual and thermal inspections of high, live, or difficult-to-access structures at onshore and offshore oil and gas installations. These are illustrated and described to include 200+ live flare inspections and 2,000+ structural inspections in 20+ countries for oil and gas supermajors. Specific ROAV inspection and survey examples and case studies are provided.

Cyberhawk: Livingston UK

For FREE Literature, select #251 at ogpe.hotims.com

Hazardous area, fire & industrial, wide area signalling products

Worldwide approved **warning signals** in three major categories with 32 product lines highlight this free 74-page catalog.

Application areas are presented in hazardous area signalling, fire and industrial signalling, and wide area signalling chapters.

Among 32 audible, visual, and/or combination warning signal products described, shown, and specified: BEx, D1x, GNEx, D2x, E2x, SpectrAlarm, AlertAlight, AlertAlarm, Sonora, Appello, Hootronic, and Spectra.

E2S Warning Signals: London & Houston

For FREE Literature, select #252 at ogpe.hotims.com

Sensors for oil & gas wells, pipelines, natural gas supply, petrochemicals

Vibration and pressure transmitters, accelerometers, and pressure sensors are described and shown in this free four-page brochure for use on oil or gas wells and pipelines.

Designs are cited to offer hazardous area approvals for a wide range of petroleum, natural gas, and petrochemical duties.

Piezoelectric pressure sensors are presented to detect and monitor dynamic pressure spikes, pulsations, and surges in gaseous or liquid media. Specific sensing instruments are called out for use on motors and pumps, compressors, or wellheads.

IMI Sensors — A PCB Piezotronics Division: Depew NY

For FREE Literature, select #253 at ogpe.hotims.com

2016 viscometers, rheometers catalog

Announcing Brookfield Engineering Laboratories' recent acquisition by AMETEK, this free 2016 catalog highlights **viscometers, rheometers, texture analyzers, and powder flow testers.**

Among new products introduced are DVE Digital Viscometers with new user interface and keypad. The updated design adopts the look and feel of DV1, DV2T viscometers and DV3T rheometer instrumentation.

Also featured is a option guide for RST-CC Coaxial Cylinder and RST-SST soft solids tester rheometers.

Brookfield AMETEK: Middleboro MA

For FREE Literature, select #254 at ogpe.hotims.com

Shakers employ patented "exciters' technology, 'G' force

MultiG high "G" force shakers use patented 'exciters' technology to generate and apply very high forces to the screen surface. This allows for a very low OOC when used as a cuttings dryer.

Among shaker features: up to 50 G's, high processing capacity, and better efficiency. Since the exciters also produce multi-frequency, they all but eliminate screen blinding.

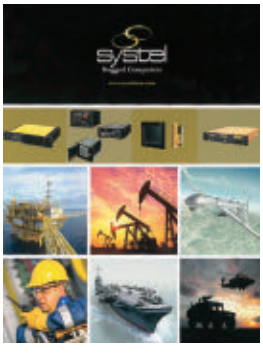
MultiG can also be used as a flow line shaker to provide a much drier discharge.

Fluid Systems: Houston

For FREE Information, select #13 at ogpe.hotims.com

Rugged oil & gas computers info folder

Military-grade custom and COTS **rugged computer**s for mission-critical oil and gas applications highlight this free information folder.



Designed to excel in harsh up/mid/downstream onshore and offshore environments, the line includes tablets, laptops, flat panel displays and computers, embedded systems, as well as rack mount servers and workstations, high performance computing, and high density storage.

Models compute in fracing, well production monitoring, wireline, as well as data acquisition processing, storage, and protection.

Systel Incorporated: Sugar Land TX

For FREE Literature, select #255 at ogpe.hotims.com

Induction heating equipment cited for pipeline construction

Offshore and onshore pipeline construction or spool base activities are served by **induction heating equipment** presented in this free 12-page brochure.

Fully and semi-automated field joint coating equipment is cited to offer "highly repeatable installation process to achieve high coating production rates, allowing for faster commissioning and reduced pipeline construction costs."

Highlighted are demagnetization and welding pre-heat, surface preparation blasting, post weld heat treatment, plus offshore, onshore, and spoolbase equipment field joint coating.

TESI Group LLC: Milan & Conroe TX

For FREE Literature, select #256 at ogpe.hotims.com

Free info: Engineering plastic solutions

Enhanced technology via **engineering plastic solutions** design and product development are emphasized in this free brochure.

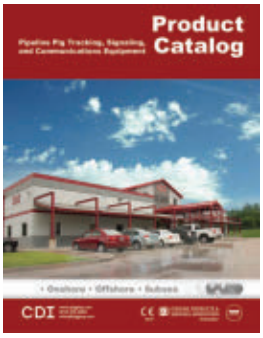
Engineered polymers, besides offering performance and cost advantages over conventional metallic components — are cited to effectively address and overcome offshore challenges, harsh environments, weight penalties, and difficult maintenance situations.

Engineered polymer materials and components advantages are cited to include ideal properties for use in salt water, exceptional wear, abrasion, corrosion, and chemical resistance, plus a weight about 1/7th of steel.

NYLACAST: Leicester UK

For FREE Literature, select #258 at ogpe.hotims.com

60-page pipeline pig tracking, signaling, communications catalog



Offshore, onshore, and subsea-applicable **pipeline pig tracking, signaling, and communications equipment** showcase this free 60-page product catalog.

Seven chapters describe, illustrate, and specify non-intrusive pig signaling systems, TRAXALL multi-frequency pig tracking systems, 22-Hz (legacy) pig tracking and locating systems, above ground markers and satellite notification systems, acoustic tracking systems, inline inspection tool systems, and accessories.

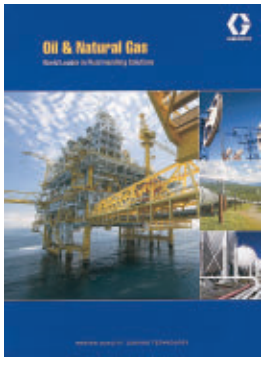
CD51 Bandit Magnetic Pig Passage Signaler is cited to detect any pig moving between 0.01 and 20-meters per second.

CDI: Broken Arrow OK

For FREE Literature, select #259 at ogpe.hotims.com

*Free Information or literature — **Click the link***

Chem injection pumps for oil, natural gas



A new line of **solar-powered, electrically operated, and pneumatically operated chemical injection pumps and systems** are announced in this free 20-page brochure.

Specifically designed for oil and natural gas applications, models are cited to dispense and monitor a large variety of production chemicals in demanding, remote conditions.

The manufacturer's corrosion protection sprayers, automatic lubrication systems, foam and polyurea proportioning equipment, pressure washers, process pumps, and Passive Fire Protection sprayers are also presented.

Its recent acquisition of High Pressure Equipment Company and Alco Valves Group is also noted.

Graco: Minneapolis MN

For FREE Literature, select #260 at ogpe.hotims.com

Arc-resistant motor control centers

Newly introduced **FlashGard motor control centers** prevent arc flash events plus protect personnel should they occur.

This arc-preventative and arc-resistant technology combination — within a single motor control center — delivers prevention, insulation, and isolation. This supports safety during routine maintenance in oil and gas or other industrial applications.

Unlike conventional motor control centers, FlashGard can be disconnected and reconnected to the vertical bus with the unit door closed. This maintains a dead-front barrier during maintenance for enhanced operator safety. Models also incorporated RotoTrack racking mechanism to provide bus isolation, stab indication, and lockout for proactive arc flash initiation prevention.

Eaton Electrical Incorporated: Arden NC

For FREE Information, select #15 at ogpe.hotims.com

Mission-critical industrial displays, panel computers

This free brochure presents "a comprehensive range of **industrial displays and panel computers** that are enriched with an array of critical features to ensure their durability and reliability in mission-critical applications."

Five panel computers and four industrial displays are described, illustrated, and specified as ruggedly designed for reliable use in harsh oil and gas environments. Such features as wide operating temperature range, IP66-rated waterproof and dustproof front panel, glove-friendly multi-touch screens, and sunlight-readable screens are emphasized.

MOXA: Brea CA **For FREE Literature, select #261 at ogpe.hotims.com**

Field-installed sucker rod centralizers / paraffin scrapers data

ULTRA-FLOW field-installed sucker rod centralizers / paraffin scrapers highlight this free datasheet. They deliver full-circle wiping of tubing inside diameter with no sucker rod-rotating required.

Complete specs, applications, and installation details are provided along with emphasis of such features as more gripping force on sucker rods plus more fluid flow-by volume than other designs. With larger vanes and bearing surface, ULTRA-FLOW is cited to deliver longer useful life.

Oilfield Improvements Incorporated: Broken Arrow OK

For FREE Literature, select #264 at ogpe.hotims.com

Non-contact rotating and reaction type torquemeters showcased

A 56-year-old **precision torque-meters** manufacturer concisely showcases **30 non-contact rotating and reaction designs in digital, analog, special purpose configurations** in its free brochure.

With 'industries highest overload and overrange ratings," each model is shown and summarized as to lbf-in. / Nm to kNM range, mechanical overload, overrange, speed, accuracy, noise hardening, plus torque, speed, power, and energy output along with other pertinent torquemeter specifications.

S. Himmelstein and Company: Hoffman Estates IL

For FREE Literature, select #262 at ogpe.hotims.com

Clamp stud welding system literature

SWG Stud Welding system for STAUFF clamps is described and illustrated in this free product overview.

With diagrams, schematics and specs SWG is cited to cover all installation options with versatility that includes fastening elements for conduit boxes, clamping belts, and cable ties.

Besides information on SWG, the literature also presents related welder inverter, weld gun, distance adaptor, distance tube, stud retainer and the original STAUFF clamps for quick, easy, and safe installation of pipe, tube, hose, and cable.

STAUFF: Werdohl Germany & Waldwick NJ

For FREE Literature, select #265 at ogpe.hotims.com

Optimized outdoor panel PCs for oil & gas

Vulcan outdoor panel PC is described, shown, and diagrammed as "optimized for the rugged demands of the oil and gas industries" in this free brochure.

Designs are cited for US/Canada Class I Div. 2 / Zone 2 and ATEX/IECEx Zone 2 areas as they are ruggedized for any onshore or offshore application over -35° to +60° C.

Vulcan design advantages are cited to include integrated Intel i7 3rd generation processor with LED auto dimming backlit display.

Computer, display, power, environmental, standards and certification, and physical characteristics specifications are provided.

Strongarm Designs Incorporated: Horsham PA

For FREE Literature, select #263 at ogpe.hotims.com

Crude oil transfer, multiphase boosting pumps and systems

Pumps & systems designed to be "crude oil transfer and multiphase boosting solutions," are presented in this free 14-page brochure.

NEMO progressing cavity pumps and **TORNADO rotary lobe pumps** are illustrated, described, and specified for a wide range of applications that are shear sensitive, low to high viscosity, with or without solids, dilatant or thixotropic, and abrasive.

Each pump is showcased with labeled illustrations. Notes are given on why you may need multiphase fluid boosting and advantages. These include ability to handle high sand content.

NETZSCH Pumps North America LLC: Exton PA

For FREE Literature, select #266 at ogpe.hotims.com

May "Advertiser Product & Service Followup"

Companies featured here advertised their equipment, products, or services in May 2 **OG&PE products section in Oil & Gas Journal**. These summaries give you an opportunity to receive **free information or literature** on leading manufacturers' and service providers' oil and gas specialties. **Go to OGPE.com — Click "Product Info" (white typeface) at top.** You will receive prompt, complete response from these valued OG&PE media partners.

Fit & Forget: High performance Fine and Superior tubing for critical offshore applications

Fine Tubes & Superior Tubes each offer 70+ years expertise in **supplying high quality tubes**.

They work closely with customers to develop high specification 'fit & forget' tubing solutions for onshore and offshore oil and gas applications — in a wide range of stainless steel, nickel, and titanium alloys.

Fine Tubes & Superior Tube, AMETEK Specialty Metal Products: Plymouth UK

FineTubes.com and SuperiorTubes.com

For FREE Information, select #20 at ogpe.hotims.com

By any measure, AMETEK knows your petroleum process product needs

AMETEK Chandler Engineering Model 292B portable natural gas chromatographs are compact and lightweight yet include fully integrated sample handling and onboard storage for up to 1,000 sample runs.

Drexelbrook's new total tank level system (TLS) uses the latest magnetostrictive technology to provide unparalleled accuracy when measuring total tank level, interface tank level, and temperature.

AMETEK Process Instruments Model 5100 Gas Analyzers measure moisture in bulk gas or hydrocarbon streams via Tunable Diode Laser Absorption Spectroscopy.

Drexelbrook Impulse wave-guided radar level systems generate total level, distance or volumetric outputs — unaffected by variations in process material electrical characteristics.

AMETEK PMT IDT intrinsically safe pressure transmitters deliver ±0.2% full-scale accuracy for critical applications plus meet FM, ATEX, and IECEx.

AMETEK Thermox WDG-V Combustion Analyzers offer improved control and process safety as they measure excess oxygen, hydrocarbon, and combustibles in flue gas.

AMETEK U.S. Gauge all-welded process gauges comprise integrated seal for lower cost than gauges and seals purchased separately.

AMETEK Grabner MINIVAP ON-LINE process analyzers automatically monitor vapor pressure of gasoline, crude oil, and liquefied or natural petroleum gas.

AMETEK Process Instruments new IPS-4 Spectrophotometers detect and quantify thousands of chemical species — up to eight at once — to verify feedstock, intermediate, and final product quality.

AMETEK: Berwyn PA AMETEK.com

For FREE Information, select #21 at ogpe.hotims.com

Valves, fittings, tubing proven for extreme oil, gas petrochemical conditions and pressures

Count on proven **HiP valves, fittings, and tubing** to handle extreme conditions and pressures throughout oil, gas, and petrochemical needs.

Our name represents high pressure in all petroleum conditions, demands, and high pressure applications.

No one does valves, fittings, and tubing better.

High Pressure Equipment Company: Erie PA

HighPressure.com

For FREE Information, select #22 at ogpe.hotims.com

Modbus Gateway = Easier Wi-Fi for more oilfield, industrial devices, less wiring, space, power

Getting your Modbus devices connected to the network and the Internet is sometimes easy, and it sometimes very difficult. What engineers need are flexible, easily deployed solutions that meet the needs of multiple scenarios while minimizing use of additional wiring, space, and power.

MGate W5208 Wi-Fi Modbus Gateway provides all functionality of both a dedicated Wi-Fi client and full-feature Modbus RTU/ASCII to Modbus TCP gateway. It also supports general serial, DNP3, and I/O connections. This makes life easier for control engineers wanting to get connected.

MOXA: Brea CA MOXA.com

For FREE Information, select #23 at ogpe.hotims.com

TORRENT Deluge Fire Protection Valves: Watch demo, request free information

See how **BERMAD TORRENT Deluge Valves** deliver uncompromising performance and reliability — in a demonstration video. You can request free information on TORRENT's capabilities to deliver high flow capacity and minimum downtime.

BERMAD UK: Berkshire UK BERMAD.com

For FREE Information, select #24 at ogpe.hotims.com

SPY Holiday Detectors: Field proven reliable for 60 years in extreme conditions

Below zero or insane heat conditions, over and under and across some of the world's most difficult terrain — for decades Pipeline Inspection Company has understood the rigors of pipeline construction.

SPY Holiday Detectors withstand being buried, dropped from great heights, run over, and even submerged during pipeline holiday detection operations worldwide.

Pipeline Inspection Company: Houston PicLtd.com

For FREE Information, select #25 at ogpe.hotims.com

Optimal filtration for maximum performance: JONELL Filtration Group consistently delivers

Optimize your filtration performance in oil and gas production, refinery and petrochemical, or gas processing and transmission operations with **JONELL Filtration Group products, technologies, and services**.

Specifically JONELL is available to optimize filtration performance in refinery fuel gas, catalyst protection, amine gas treating, compressor protection, final product protection, and glycol dehydration.

JONELL Filtration Group: Houston JonellInc.com

For FREE Information, select #26 at ogpe.hotims.com

Rugged solenoid valves control oil/fuel oil, biofuel, natural gas, hot liquids/gases

Magnatrol high quality, two-way bronze and stainless steel valves control the flow of oil/fuel oil, biofuel, natural gas, solvents, hot liquids and gases, corrosive fluids, water, steam, and other sediment-free fluids.

The rugged, field-proven models handle up to 400°F. and 500 psig in flanged ends or NPT threads from 3/8 to 3 in. All feature continuous duty coils for all AC/DC voltages.

Magnatrol Valve Corporation: Hawthorne NJ

Magnatrol.com

For FREE Information, select #27 at ogpe.hotims.com

ATEX & IECEx rugged outdoor computer / display designed for demanding onshore, offshore tasks

Vulcan outdoor computer / display is introduced for ATEX / IECEx Zone 2, Class I Div. 2 / Zone 2.

Rugged NEMA 4X, IP66-rated design serves onshore and offshore demands that include -35° to +60° C., being constructed of all-corrosion-resistant materials.

Strong Arm Designs Incorporated: Horsham PA strongarmenergy.com For FREE Information, select #28 at ogpe.hotims.com

BOP shutoff, valve control emergency power supplies data

ASB Aerospatiale Batteries are presented in this free datasheet as **emergency power supplies**.

For powering BOP shutoff and valve control, they typically deliver 5 to 60 Kw with peaks up to four-times the average power value.

The batteries are designed to safely operate in any severe mechanical, temperature, or pressure environment and to withstand high vibration, shock, or acceleration.

ASB: Bourges France

For FREE Literature, select #268 at ogpe.hotims.com

New copper-based drilling compound

HONEY KOTE **copper-based drilling compound** is introduced as specially formulated to provide maximum drill collar and drill pipe protection against seizing, galling, and load-bearing stress.

With protection against corrosion and water wash-out, the new formula, subject of this datasheet, applies easily in wide temperatures and working conditions. It will not run off or bleed at high temperatures or harden in storage.

BESTOLIFE Corporation: Dallas

For FREE Literature, select #270 at ogpe.hotims.com

Complete downhole tools HPHT testing

15 high pressure, high temperature testing services for downhole tools are summarized and charted in this datasheet.

This 40-year-old company offers pressure test fully instrumented tools with payloads as well as the ability to recertify and/or refurbish in-service tools. Other capabilities include magnetic permeability, destructive or non-destructive tests, helium leak testing, dye penetrant tests, plus inspection with documentation. Design validation and prototype verification are offered along with testing design.

National K Works Incorporated: Houston

For FREE Literature, select #269 at ogpe.hotims.com

Turbine parts and service provider

This free datasheet declares "since 1999, IMMI Turbines has been the supplier of choice for customers seeking "the Best in Class" provider of **turbine parts and services** to the world."

Among major capabilities are field services, routine maintenance and major inspections, plus zero hour engine repairs, exchanges, and overhauls. The company has a full load testing facility up to 5 MW and 'one of the largest inventories of turbine parts in the world."

IMMI Turbines: Conroe TX

For FREE Literature, select #271 at ogpe.hotims.com

#PipelineExpo

THE PIPELINE + ENERGY EXPO™

CONSTRUCTION • OPERATIONS • INTEGRITY

MAKING CONNECTIONS IN THE PIPELINE INDUSTRY

CALL FOR ABSTRACTS ***DEADLINE EXTENDED!***

NEW Deadline to Submit: Friday, July 1, 2016

Abstracts are now being accepted for the Ninth **Pipeline + Energy Expo Conference and Exhibition**, featuring a three track Operations, Construction and Integrity Conference Schedule.

The 2017 Pipeline Energy Expo will offer energy transportation professionals a unique opportunity to meet and hear the views of major North American industry leaders. Delegates will learn about important technical and regulatory developments in construction and operational management, equipment, and practices.

Abstracts should summarize non-commercial presentations about projects and technology in at least one of the following areas:

- SCADA
- Health and Safety
- Risk Assessment
- Consequences of Failure
- Cybersecurity
- Valve Automation
- Compression
- Rehabilitation
- Expansion
- Measurement & Instrumentation
- Documentation/Record Keeping
- ROW
- Environmental Remediation
- Regulatory/Permitting
- Directional Drilling
- Trenching
- Commissioning
- Line Pipe
- Hot Tapping
- Inline Inspection
- Automated Pigging
- Hydrotesting
- IM System Integration
- Data Management
- Corrosion Control
- Direct Assessment
- Cathodic Protection Leak Detection

April 4-6, 2017 // Cox Business Center + Tulsa, Oklahoma

For more information, visit www.pipelineenergyexpo.com

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IN ASSOCIATION WITH VACUWORX | NGVOK Annual Conference 2017

P2 ENERGY SOLUTIONS

P2 Energy Solutions announced the release of P2 Forecast, a new analytics solution that generates unbiased, probabilistic oil and gas production forecasts automatically, freeing up engineers' time to focus on other engineering-intensive, value-added activities. P2 made the announcement at the Petroleum Network Education Conferences' (PNEC) 20th International Conference on Petroleum Data Integration, Information and Data Management.

P2 partnered with BetaZi – developer of the BZ Machine, a physics-based predictive analytics engine – to create P2 Forecast. The BZ Machine generates a million different physically-plausible curves and groups them into percentiles using a company's monthly production volumes. The forecasts produced by P2 Forecast are automated so the forecasts are machine-generated, no engineering time or manual intervention of any kind is ever required. Blind tests have shown P2 Forecast's projections to be much more accurate than those done by hand.

P2 Forecast also generates a full range of future production possibilities, from p1 to p99, for every well in which a company has interest and provides unbiased forecasts for tens of thousands of wells that can be produced in a matter of hours, not the weeks or months traditionally required.

AVEVA

AVEVA announced that DowAksa has standardised on AVEVA's Integrated Engineering & Design solution. Established in 2012, DowAksa develops and globally markets a broad range of products and technical services to support the growing carbon-fiber-based composites industry.

DowAksa needed to increase the efficiency and integration of engineering and design works for its existing facilities and future projects.

DowAksa is a large-scale, full-service, fully integrated provider of carbon fiber solutions for industrial applications in today's transportation, infrastructure and energy markets. Very strong and lightweight, carbon-fiber-based materials are used in a variety of applications where weight savings, emissions reduction, durability and energy efficiency are key performance factors.

HALLIBURTON

Halliburton announced that it worked with Eclipse Resources Corporation to complete hydraulic fracturing of the extended reach lateral test well known as "Purple Hayes." The Utica Shale well had a lateral length of over 18,500 feet and was completed with 124 frac stages in 24 days. The total depth was 27,046 feet, including the lateral extension which Eclipse believes is the longest horizontal onshore lateral ever drilled in the United States.

The fracturing operations performed by Halliburton utilized the company's industry-leading Q10TM pumps equipped with dual fuel technology, which performed with zero down time. In addition, SandCastle® PS-2500 units equipped with Halliburton Dust Control systems provided superior sand loading logistics while reducing the environmental footprint on site. The efficiencies achieved with this equipment allowed Eclipse to improve its daily completion rate by 20 percent over the original plan, lowering their ultimate cost per BOE

PROSEP

ProSep, an industry leading technology and service provider for integrated process solutions, announced that it will supply four ProMix™ units to a National Oil Company based in the Middle East.

According to ProSep, the ProMix™ technology can generate homogeneous and moderate shear force to the dispersed phase across the cross section of the main flow, providing a narrow uniform droplet size distribution, significantly increasing interfacial contact area, enhancing mass transfer between different flows. This will enable the client to reduce chemical consumption up to 25% compared to conventional technologies, while maintaining optimal separation performance at its gas oil separation plant.

INOVX

ClearEdge3D Inc. and INOVX Solutions Inc. are pleased to announce they have signed a collaboration agreement to better leverage both companies and their technologies. The key objective is to increase value in solutions offered by both ClearEdge3D and INOVX through efficiently creating and better utilizing and maintaining intelligent 3D models built from point clouds.

The Process industry is increasingly leveraging solutions to achieve better plant efficiency and asset reliability. Plant owners are now taking advantage of 3D models and solutions specifically designed to interoperate with all of their major business applications, which is significantly improving Inspection and Maintenance business execution. This has, in turn, led to increased demand for the creation of more accurate intelligent models that can be relied upon by these same Owner/Operators.

SCHLUMBERGER

Schlumberger announced the release of the Maze* microfluidic SARA analysis for reservoir fluids characterization. This is the first commercial application of microfluidic analysis technology in the oil and gas industry.

The Maze microfluidic SARA analysis fully automates the process for testing oil samples for saturates, aromatics, resins and asphaltenes (SARA)—coupling novel microfluidic technology with spectroscopy. This method eliminates human subjectivity enabling precise SARA measurements, while decreasing turnaround time and use of chemicals by more than 85%.

Results from the Maze microfluidic SARA analysis have industry-wide applications, including validating oil samples prior to PVT analysis, understanding physical and refining properties, assessing crude oil value, and supporting flow assurance and geochemical studies.

Microfluidic chip technology has been accepted by ASTM International Standard D7996 as the industry's best test procedure for measuring asphaltenes. More than 1,900 asphaltenes analyses

using the microfluidic chip technology and 300 SARA analyses have been successfully completed across Schlumberger's global network of research centers and reservoir laboratories.

VALLOUREC

Vallourec, a world leader in premium tubular solutions, announced that it finalized the disposal of Vallourec Heat Exchanger Tubes to American Industrial Acquisition Corporation on April 29, 2016.

This decision is in line with the Group's transformation plan and, in accordance with the agreement's terms, all the employees will be integrated into AIAC.

By joining AIAC, an industrial holding company that currently owns 20 companies in 13 countries and maintains a strong presence in France, VHET will be in an optimal position to ensure its growth. From now on, the company will market its products and services under the "Neotiss" brand.

Founded in 1976, VHET, whose consolidated revenue stands at approximately €100 million, specializes in producing titanium and stainless steel welded tubes for secondary systems in conventional and nuclear power plants as well as for the desalination, chemical, industrial and automotive markets.

VHET employs 600 people across five production sites worldwide: Venarey les Laumes in France (Burgundy), Morristown in the United States (New Jersey), Hyderabad in India, and two sites in Changzhou, China. In addition, the company employs 100 people at two joint ventures in Korea and China.

BRAEDEN ENGINEERING AND CONSULTING LLC

Braeden Engineering and Consulting LLC, a leading engineering and construction firm, has announced the introduction of its new Digital Charting System 1200 series (DCS-1200).

The DCS-1200 records and charts data collected from various types of sensors and performs tests based on parameters input by the user. While this technology has a multitude of uses including measuring temperature, torque, pH and more, its initial primary function is performing pressure tests.

The DCS-1200 package includes 12.1" touch panel PC equipped with Windows 7 Prof OS and our customizable user-friendly charting software capable of displaying multiple charts with multiple pens and simultaneously running tests based on parameters set by the user.

This fully customizable software and hardware package is built for purpose. The UPS and battery system allow for hours of mobile operation in the field when power sources are not available. This mobile system is encased within a rugged carrying case with wheels and tow-handle for easy transport. Test reports are fully customizable by the user and are presented in PDF format for easy printing and transferring; data logging and archiving is also integrated.

SUPERIOR DRILLING PRODUCTS, INC.

Superior Drilling Products, Inc. a designer and manufacturer of drilling tool technologies, and Drilling Tools International, Inc. announced the execution of a distribution agreement, establishing DTI as the exclusive distributor of SDP's patented Drill-N-Ream® well bore conditioning system in North American onshore and offshore markets, excluding the Rocky Mountain region. The Drill-N-Ream is a unique reaming assembly technology that both widens and conditions the well bore during the drilling process, eliminating the requirement for a dedicated reaming run.

DTI is a leading provider of downhole tools for the onshore and offshore drilling industry. With nine locations in North America and four international locations, DTI has been providing products and services to the world's most prominent oilfield services and exploration companies since 1984.

In exchange for the distribution rights, DTI has agreed to purchase a minimum operating fleet of

Drill-N-Ream tools in 2016. DTI's exclusive rights to provide the Drill-N-Ream to customers in the distribution territory are dependent upon achievement of certain sales objectives. The agreement is a multi-year agreement and will remain in effect subject to the performance targets being met during the term of the agreement.

FUGRO

Fugro has begun a three-year period of metocean and ice data acquisition as part of the Barents Sea Metocean and Ice Network Project. The data will help operators to better understand relevant operational uncertainties and risk factors in the region known as "The Far North."

The Norwegian Petroleum Safety Authority has recognized that the Barents Sea represents a frontier region for oil and gas exploration and in its guidance states that appropriate measures to mitigate risk should be undertaken.

Statoil is leading a Joint Industry Project (JIP) to gather additional and necessary metocean and ice data in the region. Early acquisition of data in frontier regions is key to reducing risk for operators which, in turn, offers potential cost savings, for example through appropriate selection of drilling assets for the metocean regime, and optimization of the timing of drilling campaigns. There are also numerous advantages to the JIP participants related to data sharing across a frontier region, such as increased understanding of metocean processes and their spatial extent and an extended data pool against which to validate models.

Having successfully worked with Statoil and several of the other JIP participants on a number of complex metocean measurement projects throughout Norwegian waters, Fugro was contracted for the project.

In October 2015 five Fugro-manufactured Wavescan buoys, one current- and water level-monitoring mooring, and five ice thickness and current-profiler moorings were deployed at offshore sites between Hammerfest and Svalbard. The robust Wavescan buoys, which are ideally suited for the conditions of the Bar-

ents Sea, are now collecting raw wave, current, meteorological and sea-water parameter data, processing the information and transmitting the summary data via satellite link. Real-time data are then displayed on a project-specific webpage that can be accessed by the client via secure log-in. Data from the current- and water level-monitoring mooring, and the five ice measuring rigs are being stored within the instruments' internal memories for download at service visits, which are scheduled at six-month intervals for the buoys and annually in the open water season for the ice measuring equipment.

The first service visit was undertaken in March/April 2016, following which Fugro processed, analyzed and reported data collected over the first phase of measurements. The final dataset will be produced for the JIP partners upon completion of the measurement campaign in autumn 2018.

OPENLINK

OpenLink, a global leader in trading and risk management solutions for the energy, commodities, corporate and financial services industries, announced today that Superior Plus Energy Services has selected its energy trading and risk management solution.

Superior Plus Energy Services, a business segment of Superior Plus Corp. selected OpenLink to better manage operational efficiency as its US Refined Fuels business reaches more customers. Superior Plus Energy Services has expanded its propane, heating oil, diesel fuel, gasoline and associated equipment and service business through several recent acquisitions, and today serves more than 200,000 Northeast and Mid-Atlantic US residential and commercial customers.

As Superior Plus Energy Services manages organic and acquisition driven growth across the eleven states that they serve, the company selected OpenLink's solution for an integrated approach to physical and financial deal capture with real-time analysis of risk position reporting, logistics, settlement and accounting. Leading US Refined Fuels businesses such as Superior Plus Energy Services are meeting the demands of a competitive market place with technology-driven investments into robust and scalable systems to improve management of purchasing, supply and operating leverage.

GE OIL & GAS

GE Oil & Gas has introduced a series of innovative offshore solutions to lower cost, improve reliability and reduce downtime of offshore operations. The technologies, launched at the Offshore Technology Conference in Houston, underscore the creativity of industry in finding myriad types of solutions to increase efficiencies and reduce costs.

GE Oil & Gas' innovative offshore solutions and customer partnerships introduced include a Rosneft subsidiary to use latest design in new compressor technology, High Pressure Ratio Compression (HPRC) unit. GE Oil & Gas will supply UEC-Gas Turbines JSC, an integrator and supplier of high-efficiency power equipment, with three compressor trains equipped with GE's innovative HPRC units, including gearboxes and dry gas seal consoles. The three trains will be used as part of the reinjection in the BCS Srednebotuobinskoe oil field in East Siberia, Russia, operated by Taas - Yuryakh Neftegazodobycha LLC, a Rosneft subsidiary. The compressors will be manufactured in Florence, Italy. The three trains will be delivered from GE Oil & Gas by December 2016.

GE's HPRC unit, its smallest and lightest compressor yet, requires fewer units per train, significantly reducing overall footprint by up to 50 percent. The HPRC has a shipping weight up to 30-percent lighter and has lower power consumption with 5-percent less installed power. These combined innovations allow for easier installation, increased reliability and reduced operating costs compared to traditional compression trains.

GE Oil & Gas' Flexible Pipe business is undertaking a significant investment to develop and manufacture the next generation of flexible risers by utilizing composite technology to create a 30-percent lighter flexible pipe solution. Composite Flexible Pipe expands the reach of flexible risers and flowlines into deeper waters and more challenging environments while delivering a 20-percent saving on total installed cost.

This light-weight solution is a step-change as global offshore resources shift to more remote locations with extremely complex and demanding conditions. Flexible risers have been fundamental to the development and advancement of offshore exploration by enabling the widespread use of cost-efficient floating production units, enhancing the versatility of subsea layouts and providing benefits around installation and logistics plus effectively handling dynamic motion.

GE Oil & Gas is at the forefront of developing the standards and practices for the incorporation of carbon-fiber thermoplastic composites into flexible pipe. This development incorporates industry-wide collaboration on standards with certification agencies, joint industry projects and GE's leading industrial network of Global Research Centers.

CRAIG INTERNATIONAL

Leading procurement services specialist, Craig International, has launched a 'win-win' platform to help oil and gas companies off-load surplus stock worth billions of dollars and buy products and equipment they need at competitive prices.

Craig Collaboration connects companies looking to sell stock with those looking to buy. Oil and gas companies around the world have billions of pounds of surplus stock, much of it sitting in costly storage and Craig Collaboration will allow them to realize value from this.

A radical shift in procurement in the industry, Craig Collaboration represents a major investment by Craig International in an immediate, collaborative solution towards increasing efficiency. It is already gathering momentum with several major exploration and production companies expected to start using it following its launch.

Craig Collaboration is accessed through a portal and powered by Craig

IMPORTS OF CRUDE AND PRODUCTS

	Districts 1-4		District 5		Total US		
	5-20 2016	5-13 2016	5-20 2016	5-13 2016	5-20 2016	5-13 2016	5-22* 2015
	1,000 b/d						
Total motor gasoline	911	681	23	10	934	691	775
Mo. gas. blending comp.	849	608	17	10	866	618	742
Distillate	173	49	20	3	193	52	248
Residual	146	130	68	81	214	211	192
Jet fuel-kerosine	43	97	87	178	130	275	156
Propane-propylene	63	63	20	15	83	78	92
Other	962	718	113	85	1,075	803	710
Total products	**2,298**	**1,738**	**331**	**372**	**2,629**	**2,110**	**2,173**
Total crude	**6,048**	**6,629**	**1,267**	**1,047**	**7,315**	**7,676**	**6,696**
Total imports	**8,346**	**8,367**	**1,598**	**1,419**	**9,944**	**9,786**	**8,869**

*Revised.
Source: US Energy Information Administration
Data available at PennEnergy Research Center.

EXPORTS OF CRUDE AND PRODUCTS

	Total US		
	5-20-16	5-13-16	*5-22-15
	1,000 b/d		
Finished motor gasoline	413	413	426
Jet fuel-kerosine	170	170	160
Distillate	949	949	1,025
Residual	376	376	380
Propane/propylene	699	699	449
Other oils	1,001	1,001	913
Total products	**3,608**	**3,608**	**3,353**
Total crude	**390**	**390**	**441**
Total exports	**3,998**	**3,998**	**3,794**
NET IMPORTS			
Total	5,946	5,789	5,075
Products	(979)	(1,498)	(1,180)
Crude	6,925	7,287	6,255

*Revised.
Source: Oil & Gas Journal
Data available at PennEnergy Research Center.

CRUDE AND PRODUCT STOCKS

District	Crude oil	Motor gasoline		Jet fuel, kerosine	Fuel oils		Propane-propylene
		Total	Blending comp.		Distillate	Residual	
	1,000 bbl						
PADD 1	18,911	68,276	64,370	10,529	55,940	10,306	3,434
PADD 2	156,898	52,047	45,756	6,256	32,281	1,448	19,461
PADD 3	278,831	82,218	72,319	15,926	46,683	24,833	49,063
PADD 4	24,891	7,519	5,378	723	3,239	174	[1]2,171
PADD 5	57,538	30,050	27,947	9,704	12,734	5,012	—
May 20, 2016	**537,069**	**240,110**	**215,770**	**43,138**	**150,877**	**41,773**	**74,129**
May 13, 2016	**541,294**	**238,068**	**213,763**	**43,151**	**152,161**	**41,914**	**74,216**
May 22, 2015[2]	**479,364**	**220,628**	**195,539**	**38,454**	**128,838**	**40,324**	**73,219**

[1]Includes PADD 5. [2]Revised.
Source: US Energy Information Administration
Data available at PennEnergy Research Center.

REFINERY REPORT—MAY 20, 2016

District	REFINERY OPERATIONS		REFINERY OUTPUT				
	Gross inputs	Crude oil inputs	Total motor gasoline	Jet fuel, kerosine	Fuel oils: Distillate	Fuel oils: Residual	Propane-propylene
	1,000 b/d						
PADD 1	1,177	1,188	3,259	82	351	43	163
PADD 2	3,528	3,525	2,560	255	944	51	396
PADD 3	8,719	8,663	2,140	837	2,661	219	1,001
PADD 4	613	616	327	35	197	12	[1]199
PADD 5	2,396	2,286	1,619	362	508	135	—
May 20, 2016	**16,433**	**16,278**	**9,905**	**1,571**	**4,661**	**460**	**1,759**
May 13, 2016	**16,571**	**16,371**	**10,027**	**1,634**	**4,769**	**438**	**1,777**
May 22, 2015[2]	**16,727**	**16,451**	**9,961**	**1,636**	**4,891**	**397**	**1,652**
	18,317	**Operable capacity**	**89.7**	**utilization rate**			

[1]Includes PADD 5. [2]Revised.
Source: US Energy Information Administration
Data available at PennEnergy Research Center.

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

OIL&GAS JOURNAL online research center. PennEnergy research

OGJ CRACK SPREAD

	5-27-16*	5-29-15*	Change	Change, %
	$/bbl			
SPOT PRICES				
Product value	64.68	78.38	(13.70)	(17.48)
Brent crude	47.77	61.57	(13.80)	(22.41)
Crack spread	16.91	16.81	0.10	0.58
FUTURES MARKET PRICES				
One month				
Product value	66.37	82.33	(15.96)	(19.39)
Light sweet crude	49.04	58.38	(9.34)	(15.99)
Crack spread	17.32	23.95	(6.63)	(27.67)
Six month				
Product value	62.15	76.36	(14.22)	(18.62)
Light sweet crude	50.70	59.78	(9.08)	(15.19)
Crack spread	11.45	16.59	(5.14)	(30.97)

*Average for week ending.
Source: Oil & Gas Journal
Data available at PennEnergy Research Center.

OGJ GASOLINE PRICES

	Price ex tax 5-25-16	Pump price* 5-25-16	Pump price 5-27-15
	¢/gal		
(Approx. prices for self-service unleaded gasoline)			
Atlanta	160.4	209.8	255.1
Baltimore	171.8	222.8	259.1
Boston	169.9	214.8	262.1
Buffalo	164.1	225.1	272.2
Miami	159.2	214.1	265.2
Newark	169.2	202.1	250.1
New York	185.8	246.8	291.1
Norfolk	203.1	243.8	241.2
Philadelphia	153.3	222.1	285.1
Pittsburgh	171.0	239.8	282.1
Wash., DC	195.9	237.8	272.2
PAD I avg	173.1	225.4	266.9
Chicago	226.9	275.4	299.4
Cleveland	175.1	221.5	261.1
Des Moines	177.1	227.5	265.1
Detroit	176.6	225.5	261.1
Indianapolis	179.3	227.6	253.1
Kansas City	176.8	212.5	240.1
Louisville	180.1	224.5	284.0
Memphis	186.8	226.6	245.1
Milwaukee	165.3	216.6	269.1
Minn.-St. Paul	171.5	218.5	261.1
Oklahoma City	171.3	206.7	248.1
Omaha	179.5	225.6	256.4
St. Louis	172.9	208.6	264.0
Tulsa	172.3	207.7	245.1
Wichita	170.3	212.7	247.1
PAD II avg	178.8	222.5	260.0
Albuquerque	170.4	207.7	251.4
Birmingham	165.4	204.6	242.1
Dallas-Fort Worth	164.8	203.2	249.8
Houston	165.5	203.9	241.8
Little Rock	168.5	208.7	241.2
New Orleans	164.9	203.3	238.8
San Antonio	165.5	203.9	236.8
PAD III avg	166.4	205.1	243.2
Cheyenne	179.9	222.3	253.8
Denver	191.2	231.6	259.0
Salt Lake City	185.6	233.5	291.2
PAD IV avg	185.6	229.1	268.0
Los Angeles	255.0	314.0	396.4
Phoenix	182.4	219.8	284.8
Portland	178.5	228.0	310.0
San Diego	219.1	278.1	392.1
San Francisco	228.9	287.9	396.2
Seattle	198.1	261.0	322.5
PAD V avg	210.3	264.8	350.3
Week's avg.	**180.2**	**226.9**	**272.5**
May avg.	**176.1**	**222.8**	**267.0**
Apr. avg.	**161.9**	**208.6**	**245.7**
2016 to date	**150.3**	**197.0**	—
2015 to date	**190.5**	**236.1**	—

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

BAKER HUGHES RIG COUNT

	5-27-16	5-29-15
Alabama	—	2
Alaska	5	10
Arkansas	—	6
California	5	10
Land	5	10
Offshore	—	—
Colorado	16	41
Florida	—	1
Illinois	1	4
Indiana	1	—
Kansas	2	13
Kentucky	3	—
Louisiana	48	67
N. Land	16	27
S. Inland waters	5	2
S. Land	4	10
Offshore	23	28
Maryland	—	—
Michigan	—	—
Mississippi	3	2
Montana	—	—
Nebraska	—	2
New Mexico	18	48
New York	—	—
North Dakota	22	77
Ohio	11	23
Oklahoma	59	106
Pennsylvania	16	47
South Dakota	—	—
Texas	173	369
Offshore	—	1
Inland waters	—	—
Dist. 1	15	56
Dist. 2	12	43
Dist. 3	6	19
Dist. 4	7	22
Dist. 5	1	6
Dist. 6	7	17
Dist. 7B	1	2
Dist. 7C	20	34
Dist. 8	93	138
Dist. 8A	7	14
Dist. 9	2	3
Dist. 10	2	14
Utah	3	7
West Virginia	10	18
Wyoming	7	22
Others HI-1	1	—
Total US	**404**	**875**
Total Canada	**43**	**98**
Grand total	**447**	**973**
US oil rigs	316	646
US gas rigs	87	225
Total US offshore	24	29
Total US cum. avg. YTD	**505**	**1,209**

Rotary rigs from spudding in to total depth.
Definitions, see OGJ Sept. 18, 2006, p. 46.
Source: Baker Hughes Inc.
Data available at PennEnergy Research Center.

OGJ PRODUCTION REPORT

	[1]5-27-16	[2]5-29-15
	1,000 b/d	
(Crude oil and lease condensate)		
Alabama	20	29
Alaska	504	494
California	545	616
Colorado	306	313
Florida	5	6
Illinois	19	24
Kansas	99	132
Louisiana	1,322	1,367
Michigan	13	19
Mississippi	54	71
Montana	63	87
New Mexico	368	400
North Dakota	1,070	1,169
Ohio	70	60
Oklahoma	350	343
Pennsylvania	15	21
Texas	3,590	3,758
Utah	84	110
West Virginia	18	27
Wyoming	204	242
Other states	50	53
Total	**8,769**	**9,341**

[1]OGJ estimate. [2]Revised. Source: Oil & Gas Journal.
Data available at PennEnergy Research Center.

US CRUDE PRICES

	5-27-16 $/bbl*
Alaska-North Slope 27°	30.62
Light Louisiana Sweet	44.70
California-Midway Sunset 13°	40.25
California Buena Vista Hills 26°	46.83
Wyoming Sweet	45.58
East Texas Sweet	43.75
West Texas Sour 34°	40.75
West Texas Intermediate	45.75
Oklahoma Sweet	45.75
Texas Upper Gulf Coast	39.50
Michigan Sour	37.75
Kansas Common	44.75
North Dakota Sweet	36.00

*Current major refiner's posted prices except N. Slope lags 2 months. 40° gravity crude unless differing gravity is shown. Source: Oil & Gas Journal. Data available at PennEnergy Research Center.

WORLD CRUDE PRICES

OPEC reference basket Wkly. avg. 5-27-16 **$/bbl 44.65**

	Mo. avg., $/bbl Mar.-16	Apr.-16
OPEC reference basket	34.65	37.86
Arab light-Saudi Arabia	34.74	38.22
Basrah light-Iraq	33.39	36.62
Bonny light 37°-Nigeria	38.53	41.51
Es Sider-Libya	37.51	40.48
Girassol-Angola	38.42	41.25
Iran heavy-Iran	33.23	36.65
Kuwait export-Kuwait	32.99	36.33
Marine-Qatar	35.49	38.97
Merey-Venezuela	25.83	28.84
Minas 34°-Indonesia	34.62	38.52
Murban-UAE	40.01	42.47
Oriente-Ecuador	31.45	35.04
Saharan blend 44°-Algeria	39.41	42.33
Other crudes		
Fateh 32°-Dubai	35.15	39.00
Isthmus 33°-Mexico	35.45	38.14
Brent 38°-UK	38.51	41.48
Urals-Russia	36.87	39.89
Differentials		
WTI/Brent	(0.74)	(0.53)
Brent/Dubai	3.36	2.48

Source: OPEC Monthly Oil Market Report.
Data available at PennEnergy Research Center.

REFINED PRODUCT PRICES

	5-20-16 ¢/gal		5-20-16 ¢/gal
Spot market product prices			
Motor gasoline (Conventional-regular)		No. 2 Distillate Low sulfur diesel fuel	
New York Harbor	161.80	New York Harbor	149.00
Gulf Coast	147.50	Gulf Coast	145.00
		Los Angeles	154.10
Motor gasoline (RBOB-regular)		Kerosine jet fuel	
New York Harbor	154.50	Gulf Coast	137.80
No. 2 heating oil		Propane	
New York Harbor	142.30	Mont Belvieu	52.30

Source: EIA Weekly Petroleum Status Report.
Data available at PennEnergy Research Center.

IHS PETRODATA RIG COUNT

MAY 27, 2016

	Total supply of rigs	Marketed supply of rigs	Marketed contracted	Marketed utilization rate (%)
US Gulf of Mexico	111	61	41	67.2
South America	60	56	46	82.1
Northwest Europe	105	86	71	82.6
West Africa	67	55	29	52.7
Middle East	166	157	121	77.1
Southeast Asia	91	78	38	48.7
Worldwide	830	705	507	71.9

Source: IHS Petrodata
Data available in PennEnergy Research Center

US NATURAL GAS STORAGE[1]

	5-20-16	5-13-16	5-20-15	Change, %
	bcf			
East	511	490	395	29.4
Midwest	629	606	387	62.5
Mountain	171	166	128	33.6
Pacific	298	293	304	(2.0)
South Central	1,216	1,199	856	42.1
Salt	372	371	256	45.3
Nonsalt	844	828	598	41.1
Total US	**2,825**	**2,754**	**2,070**	**36.5**
	Mar.-16	**Mar.-15**	**Change, %**	
Total US[2]	**2,492**	**1,483**	**68.0**	

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

PACE REFINING MARGINS

	Mar. 2016	Apr. 2016	May 2016	May 2015	Change	Change, %
			$/bbl			
US Gulf Coast						
Composite US Gulf Refinery	9.88	11.48	10.83	14.96	(4.13)	(27.6)
Mars (Coking)	11.13	12.86	11.82	14.86	(3.03)	(20.4)
Mars (Cracking)	7.53	8.99	8.11	11.29	(3.18)	(28.1)
Bonny Light	6.02	6.83	7.43	10.55	(3.13)	(29.6)
US PADD II						
Chicago (WTI)	11.71	14.59	15.45	19.79	(4.34)	(21.9)
US East Coast						
Brass River	6.27	8.36	9.21	11.91	(2.70)	(22.7)
East Coast Comp	7.84	10.04	10.99	13.23	(2.23)	(16.9)
US West Coast						
Los Angeles (ANS)	16.76	14.59	10.63	28.22	(17.59)	(62.3)
NW Europe						
Rotterdam (Brent)	0.11	3.14	1.63	5.18	(3.55)	(68.6)
Mediterranean						
Italy (Urals)	2.45	4.30	3.96	6.17	(2.21)	(35.9)
Far East						
Singapore (Dubai)	4.29	3.07	2.35	5.65	(3.30)	(58.4)

Source: Jacobs Consultancy Inc.
Data available at PennEnergy Research Center.

US NATURAL GAS BALANCE DEMAND/SUPPLY SCOREBOARD

	Mar. 2016	Feb. 2016	Mar. 2015	Mar. 2016-2015 change	Total YTD 2016	Total YTD 2015	YTD 2016–2015 change
				bcf			
DEMAND							
Consumption	2,375	2,697	2,617	(242)	8,201	8,699	(498)
Addition to storage	215	111	182	33	392	314	78
Exports	196	164	164	32	530	454	76
Canada	81	62	90	(9)	213	240	(27)
Mexico	105	99	74	31	304	208	96
LNG	10	3	—	10	13	6	7
Total demand	**2,786**	**2,972**	**2,963**	**(177)**	**9,123**	**9,467**	**(344)**
SUPPLY							
Production (dry gas)	2,294	2,183	2,291	3	6,773	6,607	166
Supplemental gas	5	5	5	—	16	16	—
Storage withdrawal	274	515	376	(102)	1,583	1,974	(391)
Imports	240	251	258	(18)	763	790	(27)
Canada	231	241	243	(12)	733	752	(19)
Mexico	—	—	—	—	—	—	—
LNG	9	10	15	(6)	30	38	(8)
Total supply	**2,813**	**2,954**	**2,930**	**(117)**	**9,135**	**9,387**	**(252)**

NATURAL GAS IN UNDERGROUND STORAGE

	Mar. 2016	Feb. 2016	Jan. 2016	Mar. 2015	Change
			bcf		
Base gas	4,354	4,361	4,361	4,360	2,477
Working gas	2,492	2,544	2,948	1,483	1,009
Total gas	**6,846**	**6,905**	**7,309**	**5,843**	**3,486**

Source: DOE Monthly Energy Review.
Data available at PennEnergy Research Center.

WORLDWIDE NGL PRODUCTION

	Feb. 2016	Jan. 2016	2 month average production 2016	2 month average production 2015	Change vs. previous year Volume	Change vs. previous year %
			1,000 b/d			
Brazil	89	92	91	111	(20)	(18.1)
Canada	840	804	822	700	122	17.4
Mexico	299	317	308	349	(41)	(11.6)
United States	3,329	3,303	3,316	3,040	276	9.1
Venezuela	206	206	206	212	(6)	(2.8)
Other Western Hemisphere	222	188	205	245	(40)	(16.2)
Western Hemisphere	**4,986**	**4,909**	**4,948**	**4,656**	**291**	**6.3**
Norway	395	378	387	338	49	14.3
United Kingdom	76	71	73	56	18	32.2
Other Western Europe	13	13	13	13	1	4.0
Western Europe	**484**	**462**	**473**	**406**	**67**	**16.5**
Russia	849	851	850	689	162	23.5
Other FSU	170	170	170	155	15	9.5
Other Eastern Europe	15	15	15	17	(2)	(9.1)
Eastern Europe	**1,034**	**1,036**	**1,035**	**860**	**175**	**20.3**
Algeria	521	521	521	525	(4)	(0.8)
Egypt	202	202	202	199	3	1.5
Libya	50	50	50	50	—	—
Other Africa	144	146	145	130	16	12.0
Africa	**917**	**919**	**918**	**904**	**15**	**1.6**
Saudi Arabia	1,820	1,820	1,820	1,810	10	0.6
United Arab Emirates	641	641	641	641	—	—
Other Middle East	694	694	694	690	5	0.7
Middle East	**3,155**	**3,155**	**3,155**	**3,141**	**15**	**0.5**
Australia	51	53	52	53	(1)	(1.0)
China	12	12	12	12	—	—
India	122	122	122	101	21	20.8
Other Asia–Pacific	324	321	323	324	(2)	(0.5)
Asia–Pacific	**509**	**508**	**509**	**490**	**19**	**3.9**
TOTAL WORLD	**11,084**	**10,989**	**11,037**	**10,456**	**581**	**5.6**

Totals may not add due to rounding.
Source: Oil & Gas Journal.
Data available at PennEnergy Research Center.

OXYGENATES

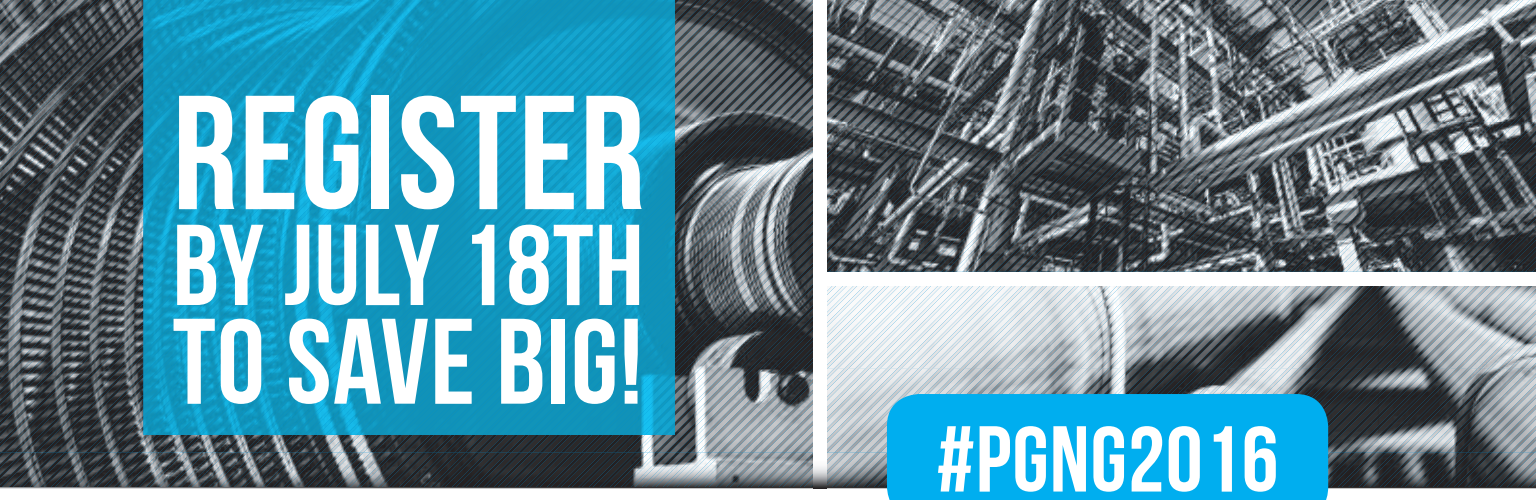
	Mar. 2016	Feb. 2016	Change	YTD 2016	YTD 2015	Change
			1,000 bbl			
Fuel ethanol						
Production	30,812	28,678	2,134	89,809	86,032	3,777
Stocks	22,301	23,004	(703)	22,301	20,865	1,436
MTBE						
Production	1,649	1,196	453	4,145	2,340	1,805
Stocks	1,183	1,213	(30)	1,183	889	294

Source: DOE Petroleum Supply Monthly.
Data available at PennEnergy Research Center.

US HEATING DEGREE–DAYS

	Feb. 2016	Jan. 2016	Feb. 2015	% change	Total degree days YTD 2016	Total degree days YTD 2015	% change
New England	954	1,130	1,415	(32.6)	2,084	2,750	(24.2)
Middle Atlantic	901	1,120	1,319	(31.7)	2,019	2,579	(21.7)
East North Central	956	1,240	1,404	(31.9)	2,196	2,739	(19.8)
West North Central	936	1,303	1,306	(28.3)	2,238	2,573	(13.0)
South Atlantic	484	662	668	(27.5)	1,146	1,312	(12.7)
East South Central	574	859	865	(33.6)	1,433	1,702	(15.8)
West South Central	309	565	499	(38.1)	872	1,122	(22.3)
Mountain	619	916	601	3.0	1,532	1,419	8.0
Pacific	343	563	330	3.9	905	798	13.4
US average*	**628**	**570**	**867**	**(27.6)**	**1,497**	**1,757**	**(14.8)**

*Excludes Alaska and Hawaii.
Source: DOE Monthly Energy Review.
Data available at PennEnergy Research Center.



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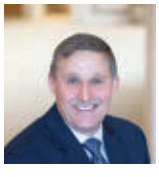

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Subsea 7 (US), LLC in Houston, Texas seeks Senior Fabrication Engineer. Qualified applicants will possess a Master's degree in Engineering or related field and three (3) years of experience in the job offered or three (3) years of subsea construction experience. In lieu, will accept a Bachelor's degree in Engineering or related field and six (6) years of experience in the job offered or six (6) years of subsea construction experience. Email resume to fhousubseahr@subsea7.com. Resume/cover letter must include job code SFEUM1.

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THE EDITOR'S PERSPECTIVE

Iranian moderates exist—in fact and political marketing

by **Bob Tippee**, Editor

Controversy over marketing of last year's nuclear deal has revived senseless assertions that Iran has no moderates.

Can all of the Islamic Republic's 77 million citizens be hardliners?

Of course not. The problem is concentration of political power in a clerical leader inclined, like all authoritarians, to rig elections and incarcerate dissidents.

The theocracy has dominated Iranian politics and oppressed Iranians since the Islamic Revolution of 1979.

The Obama administration seemed credulous, therefore, when it asserted the election of supposedly moderate President Hassan Rouhani in 2013 created the opportunity to negotiate a nuclear deal.

In fact, negotiations had begun at least a year before Rouhani's election in line with a longstanding goal of Obama for US-Iranian rapprochement.

Ben Rhodes, deputy national security adviser for strategic communications, delivered these revelations in a New York Times profile published May 5.

Rather than triggering negotiations, Rouhani's election gave Rhodes a storyline around which to promote a controversial agreement already under development.

In Iran, meanwhile, democracy continues to function at the pleasure of ruling clerics.

In February, Mehdi Khalaji, a fellow at the Washington Institute for Near East Studies, described how theocrats seeded a parliamentary election that month with candidates from the Islamic Revolutionary Guard to keep Rouhani in check (OGJ, Feb. 29, 2016, p. 23).

Khalaji also underscored the importance of a parallel election for the Assembly of Experts, which will pick the successor to aging Supreme Leader Ali Khamenei.

This month Khalaji interpreted results of a May 24 selection by the assembly of a leader for a 2-year term, Ahmad Jannati, whom the analyst describes as a "veteran hardliner" not favored by Rouhani's supporters and "the most hardline figure" among three candidates.

The outcome, Khalaji says, "confirmed what many already knew: that the recent election did not change the body's hardline fabric or the supreme leader's ability to exert his will over supposedly democratic processes."

For Iranian moderates—yes, some exist—little in politics has changed. But at least sanctions have eased.

(From the subscription area of www.ogj.com, posted May 27, 2016; author's e-mail: bobt@ogjonline.com)

WATCHING GOVERNMENT

Nick Snow
Washington Editor

Information, without politics

It was not like the usual proceedings in the Natural Resources Committee hearing room on the Longworth House Office Building's third floor. Maybe that was because no committee members attended the May 16 event.

Missing were Democrats' charges that the oil and gas industry was not doing enough to address global climate change, and Republicans' allegations that the Obama administration was extending its regulatory reach too far.

Instead, four speakers from industry, academia, and the administration discussed ways earth science advances have changed offshore energy before about 25 congressional and other federal staff members. They emphasized information instead of politics.

The American Association of Petroleum Geologists helped pull the event together with 11 other groups ranging from the US Bureau of Safety and Environmental Enforcement and US Geological Survey to the Association of American State Geologists and National Ground Water Association.

Their idea clearly was to brief congressional staffers and Department of Energy specialists on offshore energy technology changes that have occurred since 2004 and why they matter. Some of what they said was basic, but there were still some surprises.

"It's an exciting time to be working in the Gulf of Mexico. There also are a lot of challenges," said Eric van Oort, a petroleum engineering professor of at the University of Texas at Austin. "Industry is focusing more on human factors, particularly well control competence."

A little-known fact, he continued, is that the Deepwater Horizon—the semisubmersible rig destroyed in an explosion at BP's Macondo deepwater well in 2010—had successfully drilled the Tiger well for BP, which has produced millions of barrels of crude, immediately before.

"We're finding new resources that require wells in greater depths to reach deeper levels under higher pressure," said van Oort. "The rate of offshore technology development is increasing exponentially."

Improving spill response

Another speaker emphasized improvements since the blowout and massive spill. "Post-Macondo, companies came together to share resources so responses can happen more quickly," said Buford Pollett, an assistant energy law professor at the University of Tulsa. The industry specifically focused on developing technology and having enough capping stacks available to be deployed quickly, van Oort noted.

The advent of Ocean Bottom Sensor Technology produced more continuous formations in 2008 than 4 years earlier, said Kristin Wood, regional chief geologist for Shell's Deepwater North American and Brazil Exploration Group. "If you compare this to what could be shown in the 1970s, it's like night and day," she said.

It's not certain whether this briefing, and others that are planned, will lead to more sensible federal energy policies. They might increase the prospects of lawmakers and others at least having up-to-date information. OGJ

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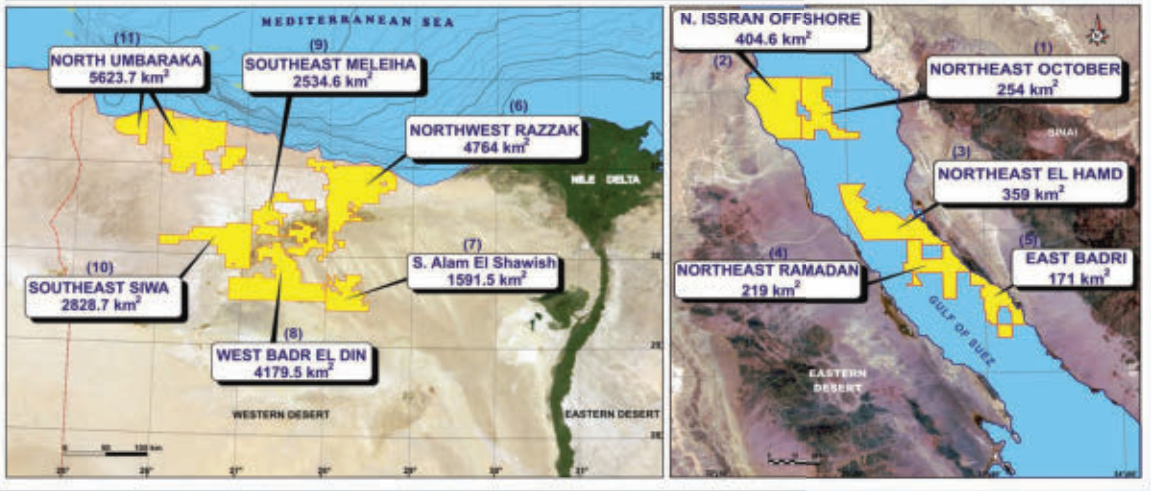
2016 BID ROUND BLOCKS



- Interested companies can submit their offers based on the announced Procedures, Main Commercial Parameters and the applied Egyptian Production Sharing Agreement Model.
- Data purchasing and data room will be available in EGPC Geological & Geophysical Information Center, Nasr City, upon request and according to the determined prices.
- Main Information, Coordinates, Procedures, Main Commercial Parameters and the Model Agreement can be obtained through EGPC web.site: www.egpc.com.eg

Closing Date: Wednesday, August 31th, 2016 at 12:00 noon, Cairo local time.

For more information, please contact:

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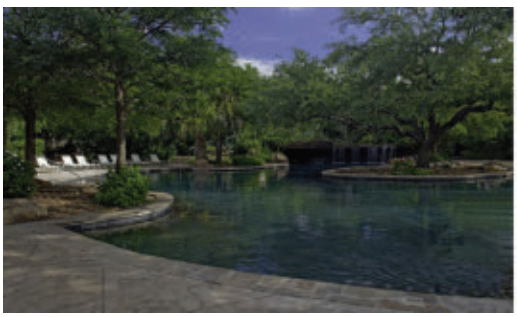
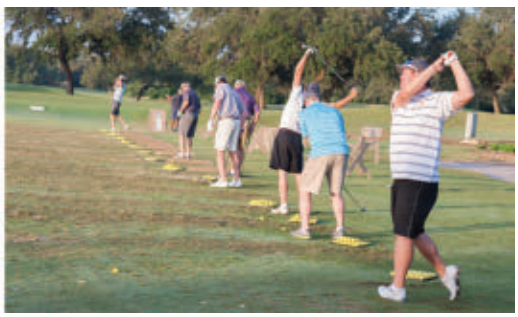
TIPRO President Ed Longanecker with Pioneer Natural Resources President & COO Timothy Dove at TIPRO's Summer Conference

TIPRO's Summer Conference also provides several opportunities to network with other members of the association and form new business connections.





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