

# Next\*

\* Chevron Technology

INGENUITY: WHEN GAS FLOWS AS LIQUID  
PARTNERSHIP: MINING NEW TALENT  
EFFICIENCY: RENEWABLE GEOTHERMAL POWER







INGENUITY



PARTNERSHIP



EFFICIENCY



**Next\***  
Issue 1, July 2006

Don Paul  
Chief Technology Officer  
Chevron Corporation

Paul Chandler  
Editor

Eileen Ostrow Feldman  
Assistant Editor

Design by DCP

**Next\***  
Chevron Corporation  
A-2  
P.O. Box 6078  
San Ramon, CA  
94583-0778

**Tell Us What You  
Think—and Join Us!**

Welcome to this first edition of *Next\**, Chevron's technology periodical. To receive future issues, simply fill in the postage-paid reply card in this issue. Also tell us what you think of *Next\**. Your views will help us shape this publication to meet our readers' needs. For an online version of *Next\** and more information about Chevron technology, visit [www.chevron.com/technology/](http://www.chevron.com/technology/).

Email:  
[comment@chevron.com](mailto:comment@chevron.com)

**On the Cover**

"Membrane" liquefied natural gas (LNG) ships, as pictured here from inside the tank, are designed to hold gas chilled to liquid form safely within the hull. Chevron Shipping Co. operates a membrane-type LNG carrier, the *Northwest Swan*, and has ordered two more of this type.

Each company affiliated with Chevron Corporation is a separate entity that manages and controls its own affairs. The use of such terms as "company," "Chevron," "organization," "its," "ours," "theirs," "we" and "us" and of abbreviated job titles is only for convenience and is not intended as an accurate description of individual status and corporate relationship.

Copyright © 2006 Chevron Corporation. All rights reserved. Material in this issue may be reprinted with permission.

Articles in *Next\**™ use terms of convenience, such as "stakeholder(s)," "partner(s)" and "partnership." Chevron does not bestow any legal right upon, or assume any legal duty to, any person, entity or group beyond those already existing by operation of governing law or regulation. Chevron specifically reserves

its full legal rights, including the right to assert all appropriate legal defenses, and no articles should be interpreted as a waiver, legal admission or acceptance of legal responsibility.

## A MESSAGE FROM DAVE O'REILLY

### Dear Friends,

For well over a century, the petroleum industry has been delivering the energy that is necessary for human and economic progress. As we look to the future, energy demand is expected to grow steadily as more and more countries build their economies and raise their standard of living. One of the world's continuing challenges will be to meet this growing demand. It will require a broad mix of energy sources and unprecedented advances in technology.

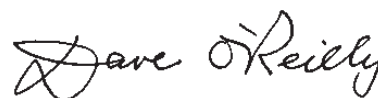
In our new technology periodical, *Next\**, you will see how Chevron is meeting this challenge on a number of

fronts: the pioneering work we have in progress to find and develop new supplies of crude oil and natural gas, the steps we are taking to deliver ever-cleaner transportation fuels, the innovative ways we are improving energy efficiency, and the advancements we are making in renewables and other forms of energy.

The stories in *Next\** also demonstrate how our approach to technology is unique in the industry. Our technology organization is fully integrated across the value chain—from exploration to product delivery—and it builds upon a powerful combination of proprietary capabilities and strong strategic partnerships.

Throughout our industry's history, technology has shaped how we produce and deliver energy. In this publication, we aim to vividly illustrate the exciting opportunities ahead as we develop the *next* technologies to deliver the energy that current and future generations will need to grow and prosper. I hope you enjoy reading *Next\**.

Sincerely,



Dave O'Reilly  
Chairman and Chief Executive Officer  
Chevron Corporation



## FEATURES

### 10 Letting Natural Gas Flow

Two technologies that transform gas into liquid offer huge potential to meet growing energy demand.

### 14 Digital Oil Fields

Multiple technologies are integrated in Chevron's emerging digital i-fields.

### 16 Heavy Oil's Incredible Journey

From reservoir to marketplace, Chevron is extracting value from the toughest raw material.

### 20 A Window on the Well

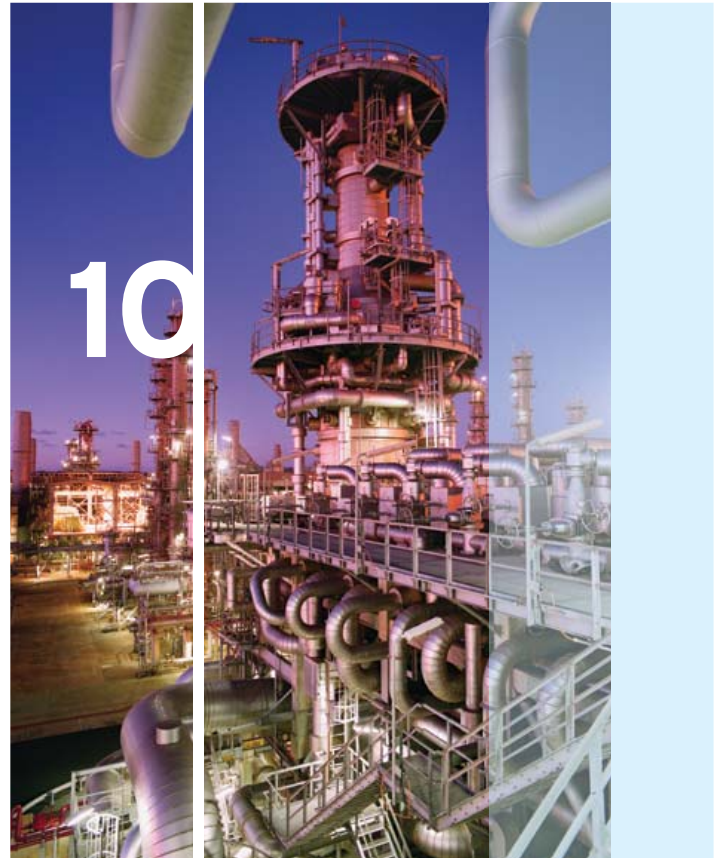
Some of the world's most complex deepwater drilling projects are made simpler through WellDECC.

### 22 The Power of Geothermal Energy

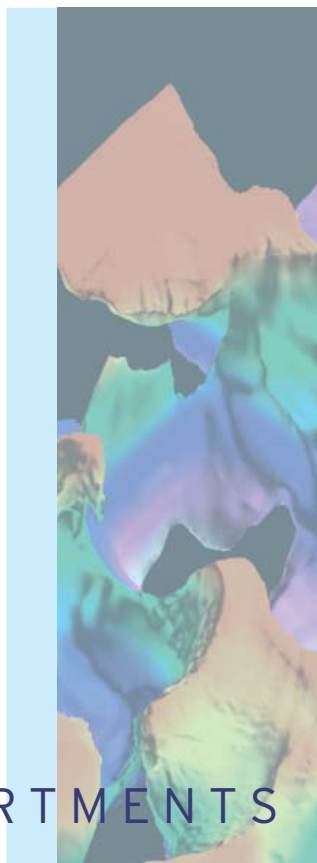
Harnessing volcanic forces brings renewable energy to Indonesia and the Philippines.

### 24 The Bigger Picture

Scientists are "seeing" beneath the earth's surface in more detail and on an unprecedented scale.







## DEPARTMENTS

### 4 Here and Now

Technology applications Chevron is developing right now to bring energy resources to market.

### 27 Vantage Point

Ashok Krishna on the future of fuels.

### 29 Next Generation

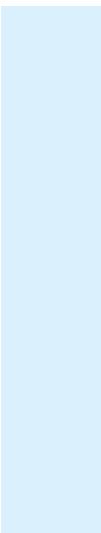
Future technologies—and the people bringing them forward.

### 34 Q & A

In conversation with Chevron's Chief Technology Officer Don Paul.

### What's Next

On the back cover: a glimpse of a future story in *Next*\*.



A government laboratory better known for its role in developing America's nuclear capabilities might seem an unlikely match with a major energy company like Chevron. A closer look at what the modern-day Los Alamos National Laboratory and Chevron bring to each other reveals a partnership with the right chemistry.

Chevron and Los Alamos announced their Alliance for Advanced Energy Solutions in November 2004. The arrangement brings to Chevron a working



Mark Puckett (left), president of Chevron Energy Technology Co., and Steve Stringer, a project leader at Los Alamos, discuss the lab's modeling theater capability, demonstrated by this model of the 6-mile-wide (10-km) meteor that struck the east coast of Yucatan, Mexico, some 65 million years ago.

## PARTNERSHIP CREATES GOOD CHEMISTRY

### Scientists draw on knowledge beyond the oil industry

relationship with world-class talent in science and technology and substantial facilities for research and development. Los Alamos is one of the largest multidisciplinary scientific institutions in the world.

On the flip side, Chevron brings to the New Mexico-based laboratory a clear view of what technical and scientific issues are challenging the oil and gas industry. John Russell, who manages the alliance for Los Alamos, says, "This is a laboratory for the U.S. Department of Energy [DOE], and part of the DOE mission is energy security. This partnership with the oil and gas industry promotes innovation supporting that mission."

Says Chevron's Manny Gonzalez, a senior engineering adviser who is the overall manager of the alliance, "Los

Alamos is a treasure-trove of technologies already developed for national security and conceivably just waiting to be quickly adapted to solve technical challenges in the oil and gas industry."

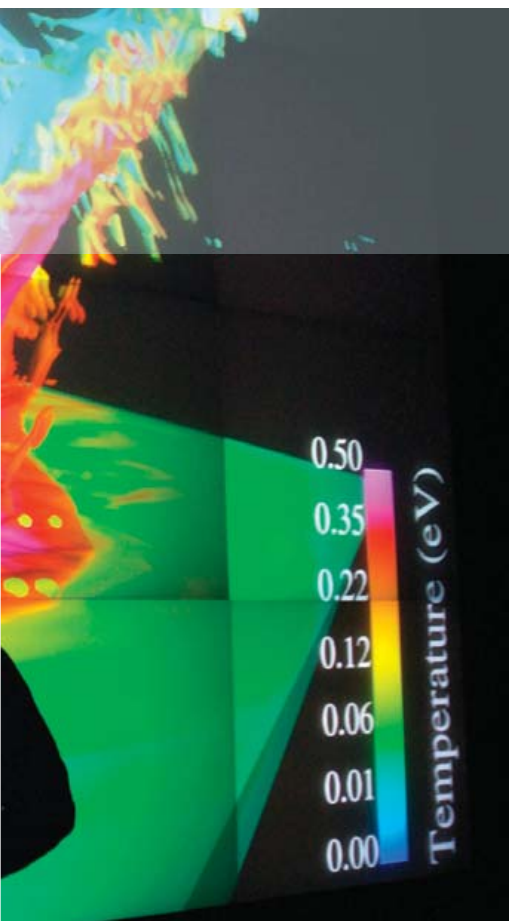
Within a year, three potential breakthroughs for crude oil and natural gas well systems were identified by the alliance: Two adapt existing technology in acoustics and wireless communications to monitor conditions in the well; one applies to a drilling challenge a surprisingly simple solution derived from the chemistry of paint.

Drilling fluid circulating in a deep-water well gets trapped behind the casing (the pipe inside the borehole) in an area called the annulus. High temperature in the well causes the fluid to expand, and that can create enough pressure around

the outside of the casing to crush it. This happens about 25 percent of the time, making the well useless.

Rob Hermes, a polymer chemist at Los Alamos, came up with a solution. "Earlier in my career, I developed high-quality plastic dye-laser rods for a military program," says Hermes, explaining that he made the rods himself in the lab. That process, carried out in a glass test tube, started with liquid-state acrylic. As the material solidified (polymerized) during the heating process, shrinkage always occurred. That was a problem because it often caused bubbles to form in the plastic. "When I heard about the drilling problem," Hermes says, "I knew what was needed: something in the drilling fluid that would make it shrink rather than expand when exposed to heat."

He was right. Methyl methacrylate monomer—a component that's found in household-variety acrylic paint—can be mixed into the drilling fluid. Heat in the



annulus, coupled with the heat generated during the polymerization reaction, causes the microscopic droplets to shrink. Just enough monomer is added to produce shrinkage of about 5 percent, offsetting the volume increase normally found in the annulus. That reduces the buildup of pressure.

"My experience had been working with the material at test tube scale," Hermes says. "Participating in the testing of this solution in a 500-foot (152-m) well and seeing it work made 2005 a really great year for me."

—Renée Silveira

## MILESTONES A roundup of recent Chevron technology achievements

Exploring the future of hydrogen as a fuel option, Chevron is the only energy company leading a U.S. government project to demonstrate natural gas reformation onsite, where hydrogen is dispensed to fuel cell vehicles. Chevron Hydrogen Co.'s second hydrogen station opened March 13, 2006, in Oakland, California (see article on Page 33).

The Benguela Belize offshore oil project in Angola—comprising a compliant piled tower with topsides that weigh more than 40,000 tons—stands in 1,300 feet (400 m) of water and is one of the tallest structures in the world. During construction, Chevron managed the engineering challenges within budget and ahead

of schedule. In December 2005, the Offshore Energy Association awarded the endeavor Project of the Year. It is the first structure of its kind to be installed outside the U.S. Gulf of Mexico. The tower and topsides were built in Angola, South Korea and the United States.

Also in December 2005, Chevron and its partners drilled the greatest depth ever in the Gulf of Mexico, at the Knotty Head No. 1 discovery well, reaching a depth of nearly 6.5 miles (10.5 km) (see related article on Page 20).

In 2005, Techron® went global. The engine-cleaning fuel additive, already in Chevron-branded gasoline in the United States, was added to the company's Texaco- and Caltex-branded gasoline. Without needing to reformulate its gasoline, Chevron was the first marketer to meet the TOP TIER detergent performance standards set by major U.S. automakers.

The U.S. Department of Energy's 2006 Annual Merit Review recognized Chevron as best-in-class for its work in hydrogen-infrastructure technology validation, specifically for the company's commitment to help find economical ways to produce hydrogen as a transportation fuel. And at the National Hydrogen Association's Annual Conference in March 2005, Chevron was presented with a special award for its leadership in hydrogen development and its sponsorship of the H2U competition, which fosters innovative uses of hydrogen technology by university students.

During March 2005, first condensate production came onstream from the Sanha Field, located in Block O offshore Angola. The project's floating production, storage and offloading vessel (FPSO, at left) holds more liquefied petroleum gas and has a larger processing column and tunnel thruster (giant propeller) than any other FPSO in the world.



Sanha—record breaker



## DELIVERING THE MAIL-AND ENERGY SAVINGS

When power interruptions struck Northern California in the early 2000s, the U.S. Postal Service (USPS) began looking for ways to reduce energy consumption and ensure reliability.

Since the 1970s, USPS had been steadily reducing energy use along federal guidelines. "But with rotating outages and high power bills, we knew we had to do more," says Ray Levinson, USPS Pacific-area environmental compliance manager. "That's when we contracted with energy

services companies, including Chevron Energy Solutions."

Chevron subsidiary Chevron Energy Solutions Co. (CES) has a track record of delivering cost savings and environmentally sound results to its clients. CES tailors projects using a range of energy options, including efficiency improvements and onsite power solutions, such as geothermal, hydrogen-based fuel cells, cogeneration, biomass and solar.

Chevron is unique among global oil majors for having a separate energy efficiency subsidiary. CES is among the five largest U.S. energy services companies. In 2005 alone, its solutions saved customers 177 million kilowatt hours of electricity and 1.19 billion cubic feet of natural gas—more than \$21 million in energy costs. The reduction in electricity translates to 97,000 metric tons of avoided greenhouse gas emissions, the equivalent of planting 60,000 acres of trees.

For the postal service, the solution was to upgrade energy systems at its largest facilities in Northern California.

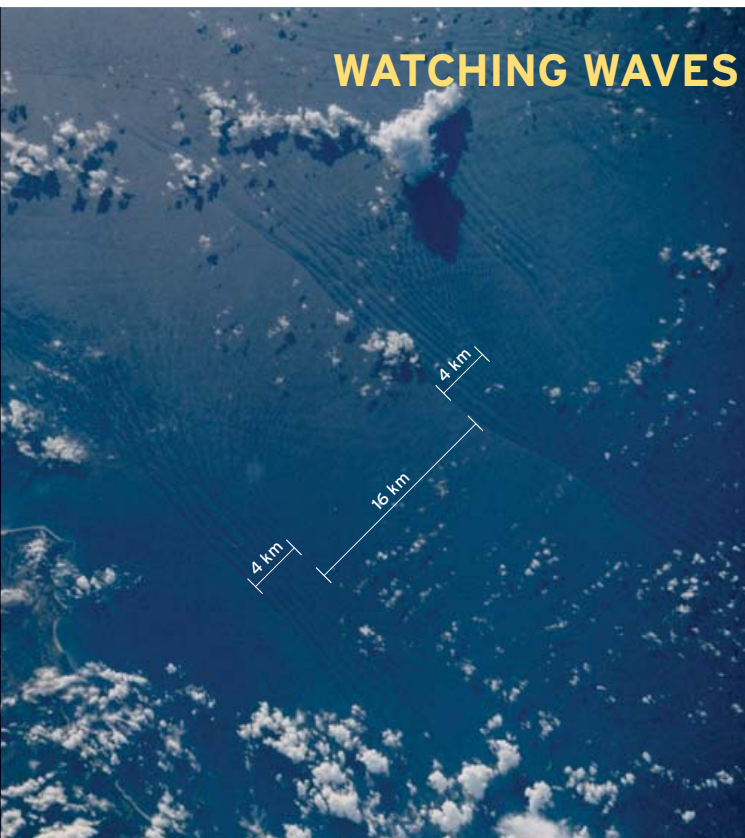
Overall, USPS expects to save more than \$2 million a year in energy costs from CES solutions at its Northern California facilities. But that's not all. As Levinson points out, "The upgrades we've made are taking pressure off the power grid, and we're greatly reducing our greenhouse gas emissions. That benefits everyone."

Satellite imagery from the space shuttle shows surface expressions of solitons offshore Hainan Island in the South China Sea. About 10 miles (16 km)—12 hours—separate the two distinct wave groups (each 4 km) seen in the photo. Each group consists of a set of solitons with individual wavelengths of approximately 0.6 mile (1 km) traveling at roughly 1 mile (1.6 km) per hour. The surface expression of these solitons is only a few inches, but the amplitude under the surface could be as much as 300 feet (91 m).

## WATCHING WAVES BENEATH THE SEA

In Western Australia, a Chevron partnership with industry, academia and government aims to keep future crude oil and natural gas production facilities safe from the ocean's biggest waves. But these monsters are barely discernible above sea level. They are solitons—the lesser-known beasts of the subsea.

While surface waves are created by wind, solitons form 100 feet to 250 feet (30.5 m to 76 m) below the surface. They usually are generated by astronomical tides that create internal waves along the density interface between the ocean's warmer upper layer and the cooler lower layer. Solitons reach







Here and Now \*

These CES-installed solar panels at De Anza College in Cupertino, California, maximize their electricity-generating capacity by tracking the movement of the sun.

## The Chevron Energy Index

Chevron has a long-standing commitment to conservation and using energy efficiently throughout its operations. In 1991, the company established the Chevron Energy Index to measure its progress in decreasing energy use. Since tracking began, Chevron has lowered its energy use by 24 percent, equivalent to adding some 45 million barrels of oil to the marketplace.

7

heights of up to 300 feet (91 m), the equivalent of a 25-story building.

"Like the wind waves we see at the beach, solitons can break on the seafloor. And when they do, they can generate forces on a pipeline that are stronger than hurricanes," says Cort Cooper, Chevron oceanographer and a leader of the joint-industry project.

Solitons occur worldwide but are particularly strong in the North West Shelf of Australia, where Chevron has several important projects, including the giant gas fields Gorgon and Ito-Ito.

This marine phenomenon is the least understood factor in the design of subsea pipelines and installations—equipment that must function reliably and withstand the forces of nature.

The technical work is being led by world-class expert Greg Ivey, the head of the Centre of Water Research at the University of Western Australia. Researchers at Stanford University and the Scripps Institute of Oceanography, both in California, are also collaborating. The goal is to develop a numerical model for predicting soliton strength during especially severe events that could occur once in a hundred years.

"Others have developed models before, but so far none has developed a solid understanding of the types of extreme nonlinear solitons we see off the North West Shelf," says Steve Cooke, Chevron's Gorgon project engineer, who played a big role in advancing the study.

It is one of 80 technology projects Chevron is pursuing under an agreement with the Western Australian Energy Research Alliance (WAERA), signed in April 2005. Key partners in the study are Chevron and Woodside Energy Ltd., the Australian oil and gas company that operates the North West Shelf Venture (the country's largest resource project, in which Chevron is a partner).

Chevron's ongoing alliance with WAERA leverages the talent and capabilities of CSIRO (Commonwealth Scientific Industry and Research Organisation, Australia's civilian federal government research and development agency), the University of Western Australia, and Curtin University of Technology. —Renée Silveira

## APPLYING LOGIC TO STRENGTHEN SECURITY

Chevron is leading a partnership to keep U.S. oil and gas control systems safe and maintain future supply

Chevron and the U.S. Department of Homeland Security are leading a partnership to tackle risks to computerized oil and gas process control systems from hackers and other unwelcome intruders. The public-private partnership is aimed at safeguarding facilities—and domestic energy supply.

A consortium including energy company peers and researchers at Sandia National Laboratories and SRI International is participating in a one-year

technology integration and demonstration project called LOGIC (Linking the Oil and Gas Industry to Improve Cybersecurity). It will be completed in July 2006, and a pilot test will follow.

"This project is examining how we can increase the security of the process control systems, not only for refineries but also for pipelines, many of which are in wide-open remote locations," says Chevron's Brian Peterson, the project manager of LOGIC. "Any significant disruption in these operations could have a devastating effect on our national energy supply," he adds. Findings ultimately will also apply to oil and gas wells and other upstream production systems.

At the Sandia lab, which is affiliated with the U.S. Department of Energy, researchers have created real-time models of control systems used for refinery and pipeline operations.

Actual process control workstations and devices—the hardware—are being used and evaluated, as are computer programming, systems and software.

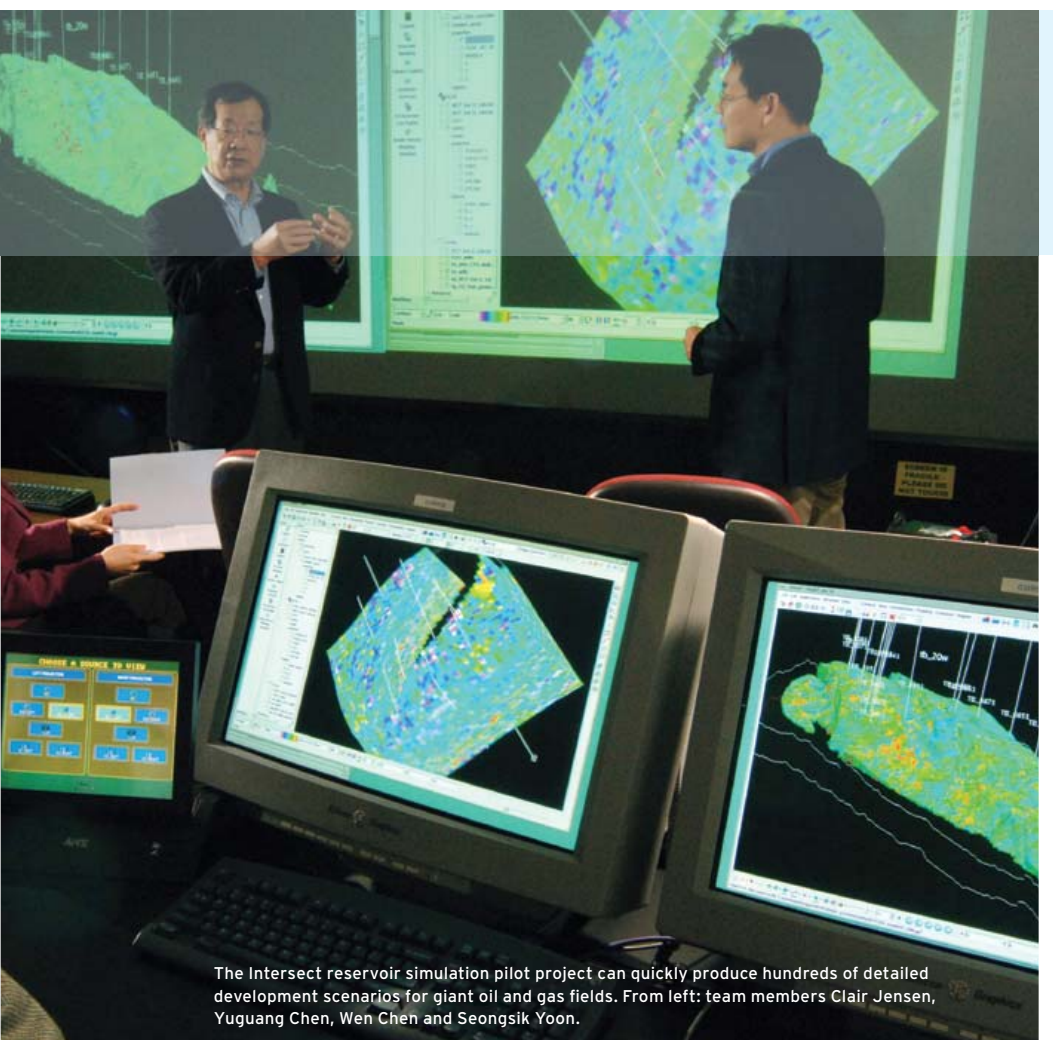
"Various cyber-attack scenarios are being simulated in combination with different security elements," Peterson explains.

The goal is to develop an analytical detector that will correlate abnormal events within the process control system with any unusual events affecting the business's computer network. These may include warnings or alerts generated by a breach of a network's firewall. "It's a layered defense approach," says Peterson.

Security improvements developed in this project will be tested within the process control systems for a part of Chevron's pipeline operations. —Renée Silveira







The Intersect reservoir simulation pilot project can quickly produce hundreds of detailed development scenarios for giant oil and gas fields. From left: team members Clair Jensen, Yuguang Chen, Wen Chen and Seongsik Yoon.

## COMPUTER FANTASY MEETS REALITY

**A new reservoir simulation tool lets Chevron play out different production scenarios before committing to costly development plans**

A major collaboration with services company Schlumberger will enable Chevron to create a clearer-than-ever picture of its oil reservoirs.

The five-year joint venture created Intersect, a blazingly fast, next-generation reservoir simulator with the promise of optimizing field development and management companywide.

Located 3 miles (4.8 km) below ground, the Tengiz reservoir in Kazakhstan is formidable: vast, hot, high-pressure and rich in toxic gas. Chevron's ability to image this onshore field's

boundaries and geologic character with computers already has enabled the company to produce oil safely and efficiently, site new wells to grow production, and reinject gas. Now, this critical work can be enhanced with Intersect.

In Houston, Texas, pilot programs are under way for Tengiz; Agbami, offshore Nigeria; Gorgon, offshore Australia; and Hibernia, offshore Canada. Three more fields will be added this year.

"What if Intersect could show us that a couple of \$50 million wells on a deep-water project aren't needed? That's the

payout potential of this tool," says Tom McMillen, Intersect project manager for Chevron. "When you simulate hundreds of development scenarios on a computer, you can identify the optimum way to reduce risk."


Simulators mimic possible reservoir behaviors, helping engineers decide where to place wells and other facilities. Despite decades of advancements, however, today's simulators are limited, says McMillen. Even when powered by the biggest computers, they can't easily handle multiple simulations.

Intersect, however, uses parallel computing, dividing big problems into pieces and solving them simultaneously—and its computer language is easier to update, a huge productivity gain over past technologies, he says.

Intersect also employs unstructured gridding, depicting reservoirs like 3-D jigsaw puzzles in a fun-house mirror, with hundreds of thousands of curvy cells, and it can grid certain areas in finer detail, explains reservoir-performance specialist Clair Jensen. By contrast, today's blocky reservoir models employ standard, cube-shaped cells that don't always conform well to geologic structures, such as sand channels, faults and pinch-outs, or to installed structures, such as horizontal and multilateral wells, all of which make reservoirs look like a partially disconnected maze of freeways.

"Earth scientists love it because the Intersect models look more like what they think is really down there," says McMillen. "We gain more confidence when we can put in more of the real physics and geology." —Jim Hendon





Chevron is a partner in Australia's North West Shelf Venture, which began liquefied natural gas production in 1989.



# Letting Natural Gas

Two technologies—one transforming natural gas into a liquid fuel, the other freezing it to a transportable fluid—offer huge potential to supply the world's future energy needs

## Flow

**I**magine a technology that transforms natural gas from Nigeria into superclean diesel to help Europe meet its motor-fuel needs and reduce air pollution—or technology that chills natural gas from Australia into supercold liquid and ships it to fuel power plants and heat homes in Asia and North America.

Only this is not imaginary. It's happening today as Chevron Global Gas links remote gas fields to markets through innovative technology.

Indeed, the company is driving a multibillion-dollar portfolio of projects intent on harnessing tens of trillions of cubic feet of natural gas resources. Long stranded by lack of markets or uncertain economics, the world's natural gas supplies are being successfully developed today through liquefied natural gas (LNG), gas-to-liquids (GTL) and long-distance pipeline projects.

### ONE SOURCE, TWO TECHNOLOGIES

Currently, LNG and GTL are the technologies offering the biggest opportunities in Chevron's strategy to deliver natural gas safely, efficiently and cost-effectively anywhere in the world.

Although they both start with simple natural gas, LNG and GTL technologies differ tremendously. LNG plants chill gas to minus 260 degrees Fahrenheit (–162° C), shrinking it to 1/600 of its normal volume for transport as liquid in tankers. Once delivered, the LNG is warmed back into a gas for distribution to customers.

By contrast, making GTL requires multiple steps, using heat, catalysis and pressure within massive reactors to synthesize GTL diesel and other valuable fuels. Among other benefits, GTL diesel is virtually free of sulfur and aromatics, so automobile exhaust emissions are minimal. Compared with conventional diesel, GTL performs like a superhigh-octane gasoline. Oil refiners can blend GTL diesel into conventional diesel to help meet stiffer air-quality rules.

### RAMPING UP

World natural gas resources are estimated to exceed 5,000 trillion cubic feet, most of which are undeveloped, and experts forecast that demand for natural gas will increase up to 70 percent by 2030.

Major markets such as Asia, Europe and North America can no longer rely on regional gas production, and imported LNG can fill the gap. These same regions have growing demand for clean-burning transportation fuels that GTL can help satisfy.

Chevron Global Gas is developing LNG export projects in Angola, Australia and Nigeria and has plans for Venezuela as well. Together, these LNG projects could produce tens of millions of tons of LNG per year destined for Asia and North America, where Global Gas is securing new LNG import capacity.

“We’re ramping up short- and long-term research and development (R&D) in both technologies,



Left: Inside the “membrane” tank of an LNG carrier. Above: Drilling-mud blending tanks at the King Bay Supply Base, which supports the North West Shelf Venture LNG plant.

collaborating with experts worldwide and looking to deploy technology solutions globally,” says Chevron’s Mike Gentry, a manager in gas technology.

#### STEADY PACE OF INNOVATION

LNG has evolved into a major industry over four decades, with steady process and technology innovations along the way.

“LNG is not a breakthrough technology but an opportunity for incremental improvements in both capital and operating expense,” says Gentry.

For example, Chevron Shipping Co. operates the *Northwest Swan*, a membrane-type LNG tanker that is fitted with a cryogenic liner and uses the ship’s hull to contain LNG. These ships carry more LNG than vessels with the same hull dimensions fitted with independent spherical tanks.

#### FLOATING LNG PLANTS

Chevron’s R&D for LNG includes offshore cryogenic loading and the development of insulated parts to transfer the supercold liquid energy. Another effort focuses on seafloor LNG pipelines, which could eliminate the need for costly trestles in export and import facilities.

The company also has shared in R&D programs that study disposal of greenhouse gases associated with energy development. Chevron’s Gorgon LNG project in Australia will include the world’s first commercial-scale carbon dioxide (CO<sub>2</sub>) injection system. The project is aiming to reinject underground about 3 million metric tons of CO<sub>2</sub> per year—similar to removing about 250,000 large passenger cars from the roads.

To help meet the geographic challenges of remote offshore gas resources and to locate future regasification terminals in new markets, Chevron is studying and investing in the development of offshore and floating LNG systems. Technologists and engineers are drawing on “a successful company history of implementing innovative solutions for offshore production,” says Gentry, adapting those lessons to the complex facilities associated with LNG.

#### THE PROMISE OF GTL

The other major goal of Chevron’s natural gas strategy is growth in the GTL business. The company’s joint venture Sasol Chevron is blending the two companies’ technical strengths to advance GTL projects and technology. Sasol Ltd. currently makes about 160,000



At a trade show in 2005, Angola's Petroleum Vice Minister Aníbal Silva (second from right) is shown a model of the planned Angola LNG project by Chevron's project team leader, Rogério Kasiala. From left are former Sonangol board member Ângelo Ribeiro and Sonangas Chairman and CEO António Orfão.



barrels per day (bpd) of synthetic fuel from coal through its patented Fischer-Tropsch process, which can also produce fuel from natural gas.

Chevron Nigeria Ltd. and the Nigerian National Petroleum Corp. are currently building a GTL plant that will use this technology to turn 300 million cubic feet of gas into 34,000 bpd of liquids, mainly synthetic diesel. If construction goes as planned, GTL diesel from Nigeria could be fueling cars and trucks in Europe by 2009.

Sasol Chevron is advancing several GTL projects with Qatar Petroleum (QP), including a base oils addition and a major expansion to the QP/Sasol Oryx GTL plant. Sasol Chevron also is marketing GTL diesel and naphtha for the 34,000-bpd Oryx facility on behalf of QP and Sasol. Sasol Chevron's first-entrant position may give the joint venture an edge in creating GTL markets, particularly in Europe.

#### EMERGING INFRASTRUCTURE

Because of GTL's huge potential, Chevron, in partnership with Air Products and Chemicals and the U.S. Department of Energy, has been investing in R&D since the late 1990s on technology that could streamline the

front end of the GTL process. These advances have the potential to reduce front-end costs of making synthetic gas a feedstock by about 30 percent. As costs fall, more GTL plants will be possible in more places.

Separately, Sasol Chevron is collaborating with Daimler Chrysler to optimize diesel engine designs for GTL fuel and is exploring other potential uses of GTL for aligning resources with product markets.

A global infrastructure to deliver natural gas is emerging, says Gentry. "Our success in this growing industry will depend on technology advances that help us deliver the gas in the most safe, efficient and cost-effective way," he says. "Chevron is making the right investments now to become a significant player in meeting global natural gas demand." —*Jim Hendon*



Gas-to-liquids joint venture Sasol Chevron is evaluating a planned \$6 billion slate of commercial-scale projects in Qatar. Sasol Chevron currently provides technical support on the Oryx GTL project, shown here, a 34,000-barrel-per-day joint venture between Qatar Petroleum and Sasol Ltd.

Integration—of multiple technologies provided by the best minds in computing and engineering—puts the “i” in Chevron’s ambitious i-field project

**C**hevron workers in the damp Piney Woods region of East Texas are on a mission to make old operations at the Carthage natural gas field achieve new feats of productivity.

The goal is to become Chevron’s first i-field—an initiative to integrate technologies in oil and gas field operations. The project already is advancing in eight Chevron fields worldwide, with more to follow. Key targets of the i-field project are long-standing, mature operations—like Carthage—and new deepwater fields.

“We want people to spend less time gathering and deciphering all kinds of different data and more time making decisions,” says Warner Williams, who oversees Chevron’s major California oil fields, including i-field target San Ardo.

Computers have dramatically improved key functions of the oil and gas business, such as exploration and

Nine technology partnerships will help make it happen. These include new information technology architecture with Microsoft, real-time production and reservoir optimization with Schlumberger, and an asset decision environment with Science Applications International.

Back at the Carthage Field, 650 wells are scattered over 1,000 square miles (2,600 sq km). It’s a landscape better suited to pickup trucks than control rooms. But technology is overtaking geography, says Victor Villagran, Carthage’s i-field project manager. Guided-wave radars report tank levels. Automated control systems adjust artificial lift wells.

Operators used to drive out and check every well. Now, hand-held devices and rugged laptop computers pinpoint wells showing early signs of problems. Instead of reacting to breakdowns and losing production, i-field crews flag and prevent failures to keep oil and gas flowing.

“In time, we’ll be able to see and manage the whole operation from a central location,” says Villagran.

Multidisciplinary integration on this scale is creating a need for a new multiskilled workforce. To meet that need, Chevron has partnered with the University of Southern California to create the Center for Interactive Smart Oil Field Technologies, offering a multidisciplinary graduate degree that combines petroleum

# Digital oil fields pumping

reservoir modeling, and operations today exhibit some i-field traits, Mike Hauser, Chevron’s i-field program manager, and colleague Trond Unneland told the Society of Petroleum Engineers in a recent presentation. But a next great productivity frontier beckons.

Carthage and the other i-fields will use developments in sensors, monitoring and optimization tools that anticipate and plan based on what’s happening real-time and continually adjust to operating circumstances. The vision is to turn crude oil and natural gas fields into factories with coordinated information-intensive technology.

engineering with information technology, math, and electrical and industrial engineering.

Hauser says that evolving toward automated “digital oil fields” is essential to address workforce productivity concerns. “In the United States and Europe alone, some 50 percent of the industry’s older workforce will be gone in three to five years.”

Early indications at Carthage are validating the expected production increases and time savings. Says Jayne Sieverding, a business development manager for Chevron Energy Technology Co.: “The digital oil field of tomorrow is closer to reality than many may think.”

—Jim Hendon



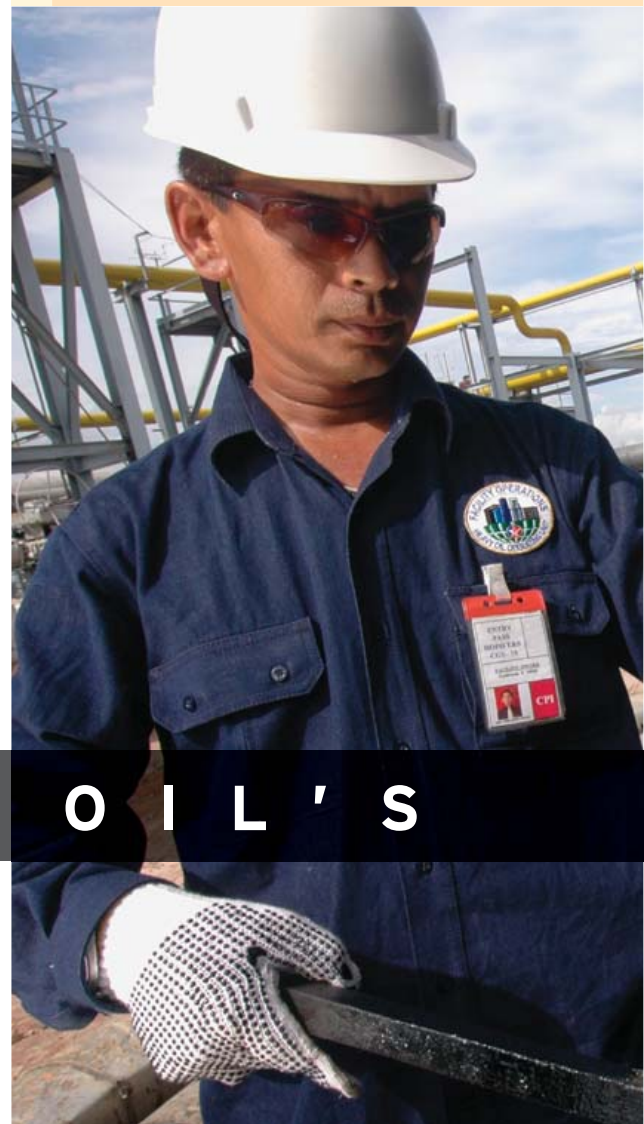
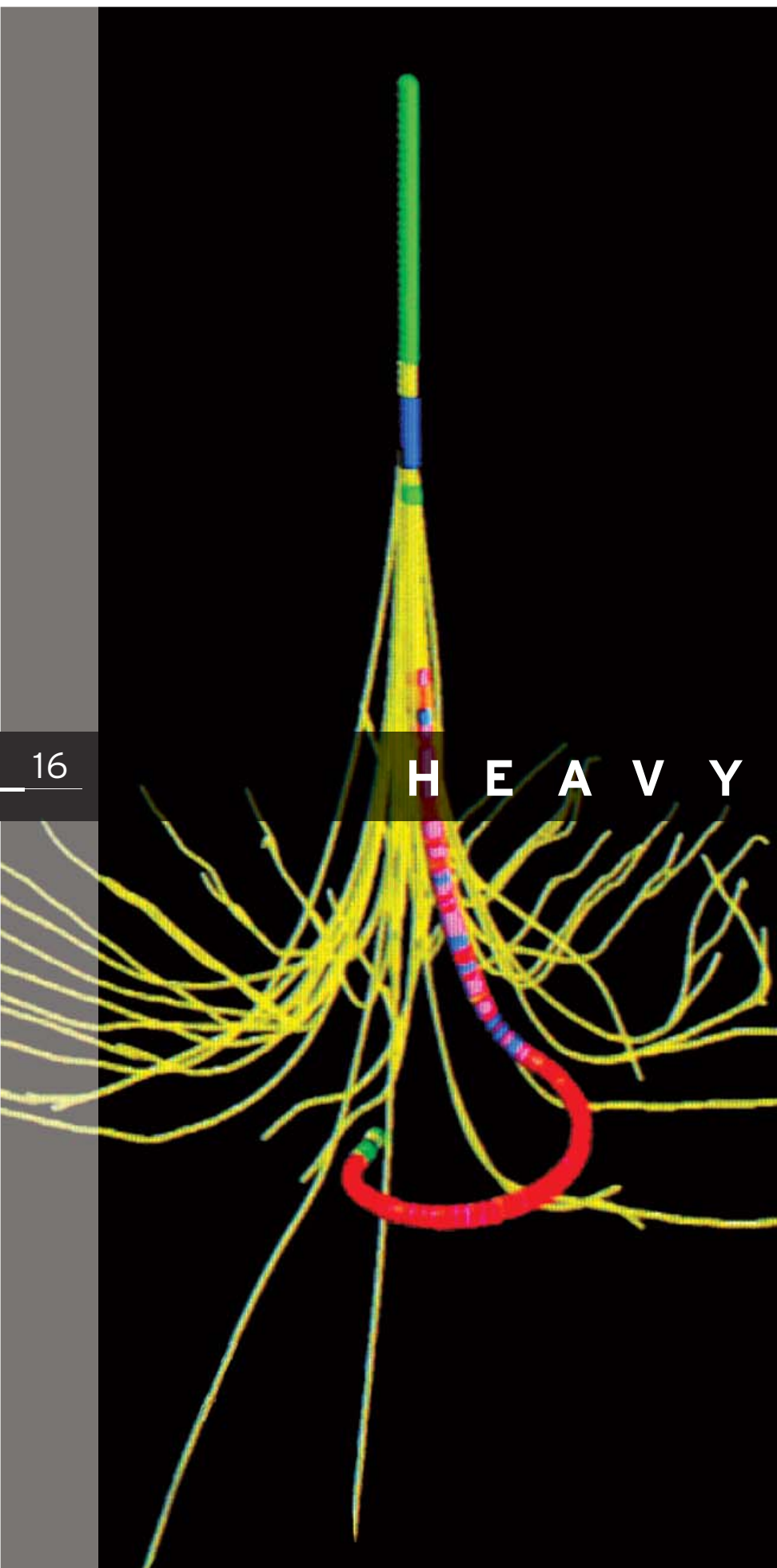
productivity from partnerships

At Chevron's Carthage natural gas field in Texas, instrumentation and electrical specialist Trent Coker monitors real-time well data from a computer in his truck.



## H E A V Y

## O I L ' S



Left: A dogleg directional well twists and turns through a web of existing horizontal wells to reach its target—the previously inaccessible heavy crude directly below the Captain platform in the U.K. North Sea.

Above: Station operator Nazirwan checks equipment for safety and environmental compliance at the Duri, Indonesia, heavy oil field.

Right: A customer fills her tank at a Chevron service station in Florida with pure but hard-won gasoline. Produced from Venezuelan heavy crude, the oil needs major upgrading even before arriving at the refinery and, ultimately, automobile tanks.



# INCREDIBLE JOURNEY

17

## From reservoir to marketplace, Chevron is extracting value from the toughest raw material

**M**onday morning, under the bright Florida sunshine, a commuter rolls into a Chevron station to buy gasoline. Three thousand miles (4,800 km) away in Venezuela, a tall pump tirelessly draws raw oil from the Hamaca Field. The thick crude is steadily pulled barrel by barrel from specialized wells probing the tight rock layers below.

What's the connection? All motor fuels begin as raw materials. But look closer and you will see ingenuity—a value chain of technologies linked to promote heavy oil

like Hamaca's to a starring role on the world energy stage. Chevron produces more than 650,000 barrels of heavy oil per day on five continents, and the Venezuela–Florida link is just one example of what's required to succeed.

Crude oil from the Hamaca Field—developed by Chevron and partners—is loaded with sulfur, metals and other elements. So the partnership built a massive upgrader to distill, filter, desulfurize and otherwise convert the sluggish stuff into synthetic crude, a



Well engineer Bobby Scott, Kern River Field, California.

process similar to oil refining. The “syncrude” is attractive to facilities like Chevron’s refinery in Pascagoula, Mississippi, which is configured to process heavy oil.

Blended with heavy Mayan crude from Mexico—the mainstay of Pascagoula’s feedstock—the syncrude helps balance the refinery’s diet to ensure that Chevron can churn out gasoline to keep customers rolling.

#### WHY HEAVY OIL?

Chevron has embraced integrated heavy oil development as a core strategy. But why deal with heavy oil when most crudes are lighter and easier to produce and refine? Answer: opportunity on a staggering scale.

Venezuela alone holds more than 1 trillion barrels of extra-heavy oil, just some of the several trillion barrels worldwide—four times the known reserves of lighter oil. As oil demand keeps rising, smart refiners will turn to troublesome but cheaper heavy crudes.

“Integrated oil companies that can access lower-cost crudes and efficiently convert them into high-demand fuels will gain competitive advantage in the new oil era,” Jeet Bindra, president of Chevron Global Refining, told the company’s 2005 Heavy Oil Forum, appropriately themed “From the Reservoir to the Marketplace.”

About a third of Chevron’s 11 billion barrels of proved oil reserves are heavy to medium-heavy, so the company specializes in key production technologies. In California’s San Joaquin Valley, teams inject steam into heavy oil reservoirs, employing sophisticated earth models, sensors and precision steam distribution.

Where previous methods captured about 10 percent of the oil in place, modern thermal techniques can



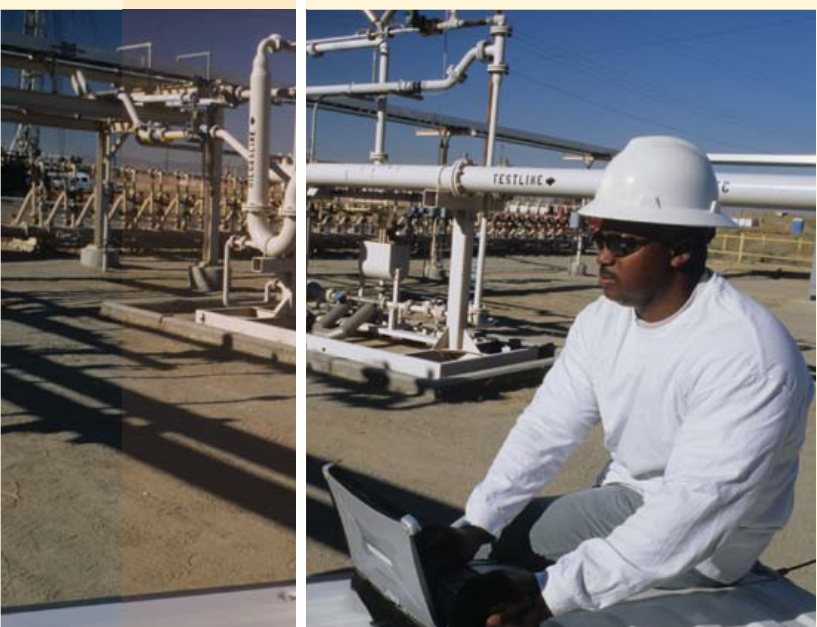
recover up to 80 percent. When Chevron migrated thermal technology to its Indonesia operations, it created the world’s largest steamflood at Duri Field.

Earlier this year, the company acquired a large tract in Canada with more than 7 billion barrels of heavy oil in place for a future project using steam-assisted gravity drainage, a next-generation thermal technology.

Meanwhile, steaming is being tested in the giant Wafra Field, operated by Chevron and partners in the Partitioned Neutral Zone between Saudi Arabia and Kuwait. Wafra won’t be easy—thermal technology success to date has primarily been in sandstones, and nobody has done a commercially successful carbonate-rock steamflood.

But tricky geology hasn’t stopped Chevron in the past. In one unique California venture, operators pump steam into tight diatomite rocks and then let the pressure push out the heavy oil. They repeat the process, like inflating and deflating a balloon.

In deeper heavy oil fields and offshore fields, thermal methods won’t work, or they cost too much. So Chevron applies other technologies.







John McCaffery is the diatomite project manager at the Kern River Field in California. His team uses steam to fracture and heat low-permeability rock in order to release and force out crude oil.



PHOTO: ALEXANDRA DOBRIN

Guided by an elaborate reservoir model, the Hamaca project drills forked wells that snake horizontally for up to a mile (1.6 km) through the oil-bearing rocks. At Chevron's Captain Field in the North Sea, horizontal wells rigged with special filters and downhole pumps curve out to tap the stubborn, medium-heavy oil. Newer Captain wells spiral like corkscrews and loop like fishhooks.

"We're pushing directional drilling technology right to the wire, but each success increases our confidence that even more complex wells are possible," says Captain's Gert de Jonge.

### HYDROPROCESSING EDGE

While upgraders like Hamaca's are a recent development, Chevron over the years has built a broad capability in refining heavy oil, with the flagship Pascagoula facility as just one element.

"Chevron has been a world leader in hydroprocessing [which helps refiners make environmentally friendly, lower-sulfur fuels] for nearly 50 years and has been licensing clean-fuels solutions to the worldwide refining industry for the past 20 years," says Ashok Krishna, general manager of technology for Chevron Global Refining (see story on Page 27).

Moreover, he says, Chevron pioneered the modern technique of high-pressure hydrocracking—using hydrogen and catalysts to make more high-value products from heavy, residual liquids left over after conventional refining skims off the lightest elements of the crude.

"Our technology gives Chevron a unique opportunity to optimize across the entire value chain," says Bindra. "We're increasing our refining network capability, with integration as a high priority." To that end, Chevron and its partners recently announced plans to retrofit their 650,000-barrel-per-day Yeosu Refinery in South Korea to handle more heavy oil. Meanwhile, improvements to heavy oil capabilities continue at the company's El Segundo Refinery in California.

Whether they fill up at Chevron stations in Florida or California or at stations sporting Chevron's Caltex brand in Seoul, commuters in the future will likely rely more on hidden value chains that link to heavy oil fields the world over. —*Jim Hendon*

Reynaldo Rodriguez (left) and Peter Wright on a walk-through of the vast Hamaca heavy oil upgrading facility in Venezuela.

# A W i n d o

WellDECC visualization technology

The *Discoverer Deep Seas*



**H**overing in 4,000 feet (1,220 m) of ocean, the drillship *Discoverer Deep Seas* lowers a steel tentacle tipped with a massive bit to the seafloor. The objective: Install an oil and gas well of progressively narrower sections 25,000 feet (7,620 m) into the earth—a precision exercise akin to threading a needle 5 miles (8 km) away.

It will take months and cost up to \$70 million. Drilling onshore or in shallower water is viewed as one task within a project. But as the industry pushes deeper, “every well is a project,” says Glenn Warner of

Chevron’s Well Design and Execution Collaboration Center (WellDECC) in Houston, Texas. Built and operated with Halliburton, Landmark Graphics, Sperry-Sun and others, WellDECC is helping Chevron reduce risk and increase precision in its growing portfolio of challenging wells.

Most mornings, you will find geologists and engineers silhouetted against WellDECC’s walls of information—earth models, graphs and images of drilling in progress. Visualizations of well paths slice through shapes representing rock layers and salt domes. In the U.S. Gulf of Mexico, teams on rigs view, via satellite, the same data in their own mini-WellDECCs.

“Our drill-site teams have a tremendously complex task, and WellDECC helps them make quality decisions,” says David Payne, vice president of Chevron’s Global Drilling and Completions. Adds Terry Gatlin, drill-site manager aboard the *Deep Seas*: “Drill ships cost companies up to \$500,000 every 24 hours. If WellDECC can help us save even one day on wells like these, it will have paid for itself.”

Far more valuable than real-time interaction, however, is WellDECC’s potential to optimize drilling before it actually starts, says Payne: “Some 85 percent of well problems can be traced back to poor subsurface modeling and associated well planning.” Superior execution based on interdisciplinary collaboration and supported by WellDECC’s technology, he believes, will help Chevron excel in the deepwater frontier.

—Jim Hendon

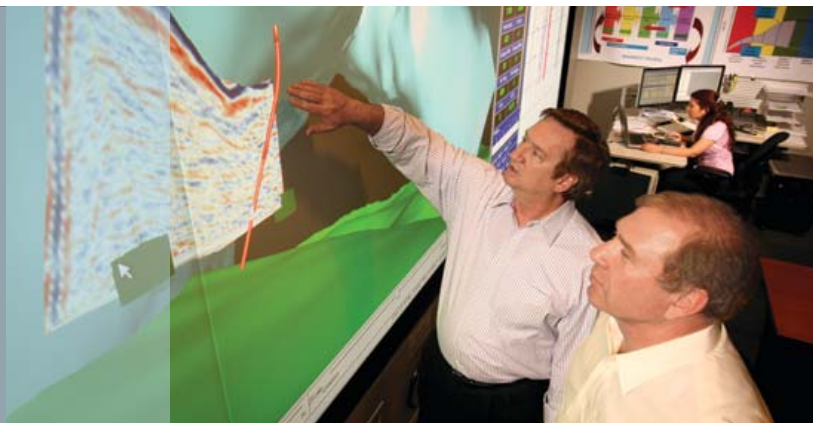
From the comfort of the Houston, Texas, WellDECC center, drilling engineers Glenn Warner (left) and Edgardys Lapierre can analyze all the data they need from a well as it is being drilled. Above: Warner and drilling engineer John Breidenthal.

PHOTO, LEFT: GREG SMITH; CENTER AND RIGHT: PAUL S. HOWELL

# on



# OW



is helping Chevron manage the most complex deepwater drilling projects

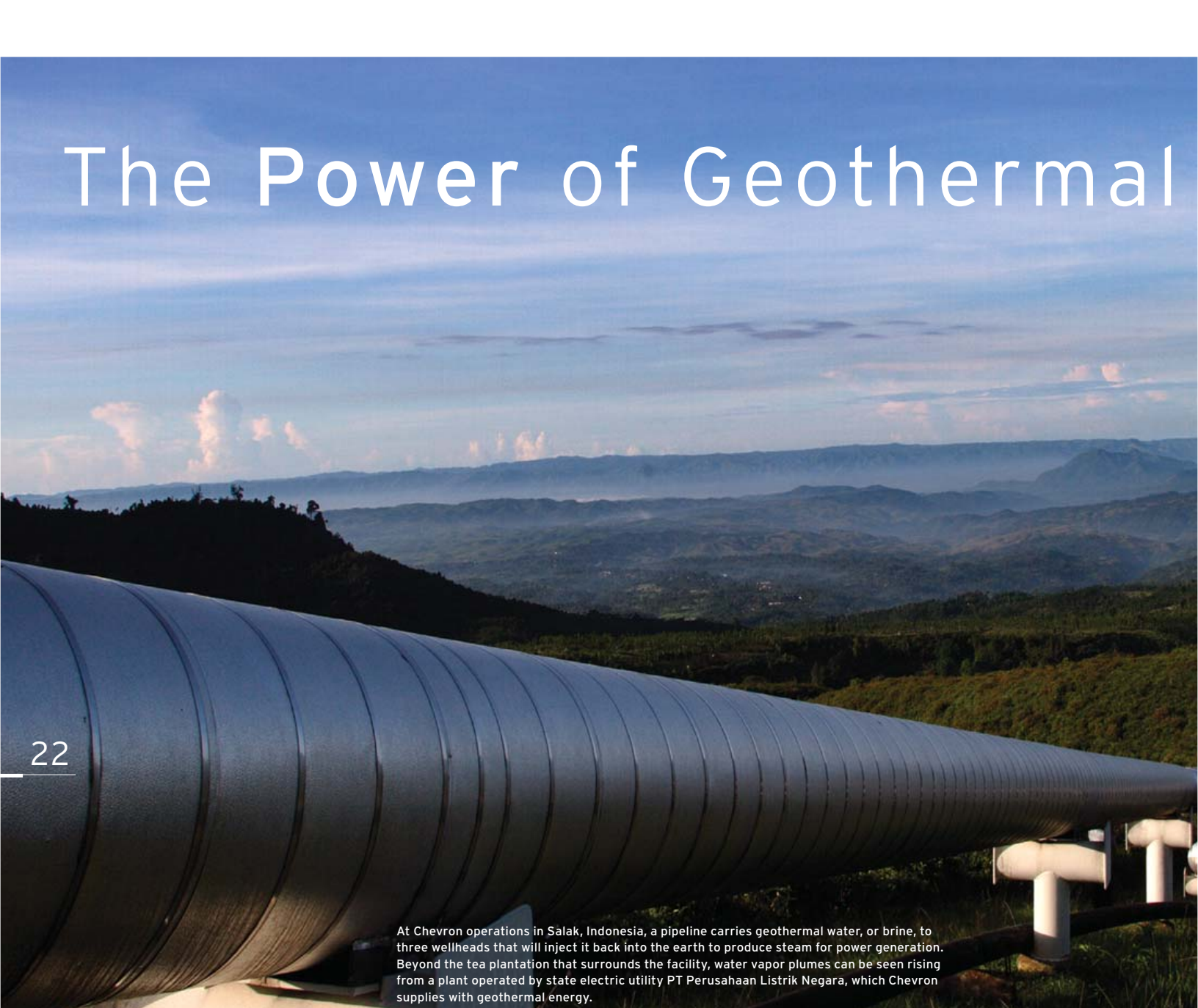


21

# the Well

# The Power of Geothermal

22



At Chevron operations in Salak, Indonesia, a pipeline carries geothermal water, or brine, to three wellheads that will inject it back into the earth to produce steam for power generation. Beyond the tea plantation that surrounds the facility, water vapor plumes can be seen rising from a plant operated by state electric utility PT Perusahaan Listrik Negara, which Chevron supplies with geothermal energy.

**W**hile crude oil and natural gas are its primary business, Chevron is the largest producer of geothermal energy in the world. For more than 30 years, the company has been capturing steam produced from subterranean volcanic activity to help meet the growing electricity needs of Indonesia and the Philippines.

In Indonesia, the power plants that Chevron currently operates are producing enough geothermal energy to meet the energy needs of a city of more than 2 million people. And that's just the beginning. A major expansion is under way at the Darajat geothermal plant in Java that will almost double electrical output.

The Philippines tell a similar story. Chevron-operated plants there supply 15 percent of the electricity required by Luzon, the largest island in the Philippines, with a population in excess of 30 million people.

"In Indonesia and the Philippines, there is great potential for developing geothermal energy," says Barry Andrews, senior vice president for Geothermal and Power. "And Chevron plans to remain at the forefront of the effort."

What makes geothermal attractive is that it is a clean, reliable and economical form of energy. Geothermal energy emits virtually no greenhouse gases, making it particularly attractive as countries work to reduce carbon



# Energy

Harnessing volcanic forces brings renewable energy to Indonesia and the Philippines



23

dioxide emissions. Another plus: It is renewable. It is derived from natural heat within the earth—and that heat is essentially limitless.

Geothermal energy is produced when groundwater descending from the earth's surface meets molten magma rising upward. Geothermal fluids are trapped in the earth's crust in reservoirs, or "pockets," typically at depths of up to 9,800 feet (3,000 m). The fluids can be recovered by drilling wells, much like traditional oil and natural gas operations. Surface facilities convert a portion of the fluids into steam, which is used to power turbines for generating electricity. Excess fluids are returned to the reservoir, thereby regenerating the steam source.

The geologic conditions necessary to create a geothermal resource exist in very few parts of the world. The most active resources are usually found along major plate boundaries, where earthquakes and volcanoes are concentrated. Most of the geothermal activity occurs in an area known as the Ring of Fire, which rims the Pacific Ocean. There, deep fractures in the earth's crust allow molten material to push close enough to the surface to heat geothermal reservoirs.

Although it is not a widespread form of energy, more than 20 countries, including the United States, meet part of their electricity needs from geothermal energy. —Patty Marshall





# The Bigg Picture

24

Chevron's reservoir-scale imaging and earth-modeling technology combine to reveal oil and gas reservoirs beneath 11,000 feet (3,353 m) of salt at the giant deepwater Tahiti Field in the U.S. Gulf of Mexico.





er

Everybody says it: The easy oil is gone. Vast quantities remain, but nature has locked them away. They're buried in places like Chevron's Tahiti Field, where the rock is hot enough to fry eggs and the pressure is like a dump truck parked on your thumbnail. If you're an engineer, that's 20,000 pounds per square inch. And

As the search for resources goes deeper, Chevron scientists are "seeing" beneath the earth's surface in more detail and on an unprecedented scale

it's 4 miles (6.4 km) under the U.S. Gulf of Mexico.

Deep water isn't the only challenge. Ancient oceans left 2-mile-high (3.2-km) swaths of salt that stretch for miles beneath the earth's surface and cover some of the company's richest reserves. Such canopies overlie Tahiti and the Tengiz and Karachaganak fields in Kazakhstan. When seismic signals—the industry's chief tool for "seeing" beneath the surface—hit such formations, they ricochet like golf balls hitting concrete.

Now Chevron's earth scientists are seeing the bigger picture. Not only can they see through salt, they're also creating reservoir-scale images of unprecedented size and clarity, revealing geologic features that have dogged the industry for years.

"We've built a leading capability in imaging the shape of structures beneath the salt," says Jeb Blackwell, exploration technology manager for Chevron Energy Technology Co. "Now we're combining that imaging capability with advances we've made in amplitude preservation to generate finer-scale reservoir images that are structurally accurate and reveal reservoir-scale features." Amplitude preservation is necessary to predict rock and fluid properties.

The reservoir-scale images are so impressive "that we've won tenders from joint-venture partners to apply this technology instead of their own," says Blackwell.

Take the example of Great White, Chevron's deepwater discovery in the Gulf of Mexico, which



Standard PCs, multiplied thousands of times, provide the computational power for Chevron's reservoir-scale imaging. Errol Blumenthal (left) and Jeb Blackwell are pictured alongside these computer clusters.

the company imaged for its joint-venture partners in 2002 and to which it recently applied its reservoir-scale imaging. "The difference is like night and day," says Blackwell. Small-scale faults invisible in the initial image are apparent now. Seismic amplitudes that may relate to rock and fluid properties are visible. "With this kind of modeling, we'll find more oil and gas than we could in the past," he adds.

Chevron's reservoir-scale images wouldn't be possible without two key competencies and one powerful enabler.

### THREE KEY INGREDIENTS

No. 1: The company's pre-stack depth migration (PSDM) algorithm is among the industry's most efficient. Scientists use it to process seismic data in less computing time than it takes competitors, allowing geologists to test more alternative earth-model solutions and produce a better final decision for drilling.

No. 2: Scientists use standardized in-house work flows to remove noise and preserve amplitudes. That's important: The imaging algorithms work properly only if the input data accurately reflect the true earth properties. Poor imaging resulting from incorrect input data or the wrong earth model can have multimillion-dollar consequences, including dry holes.

No. 3: But these two competencies wouldn't produce fast, vast, fine-scale images if it weren't for the third ingredient—cluster computers. Using technology similar to that found in a standard PC, thousands of central processing units are combined with vast disk storage space. "The clusters are faster and cheaper than anything we could have imagined just a few years ago," says Errol Blumenthal, PSDM leader.

### THE POWER OF CLUSTERS

The computational efficiency built into Chevron's depth-imaging code, supported by the power of the clusters, converts enormous seismic data sets—up to several terabytes per copy—into vast, visual images. "And we're creating these images faster and cheaper than anyone in the industry," says Blackwell. Adds Blumenthal: "We designed the computers for the code and the code for the computers. You can't separate the two."

After purchasing raw seismic data from vendors, Chevron's scientists create velocity models, making assumptions about the speed the seismic energy—or sound waves—traveled within various rock layers. Regional geologic knowledge is key. Scientists need to know the rock types, and if salt is present, its shape.

Next, they run the model through Chevron's amplitude work flow, removing noise and preserving amplitudes that relate to oil and gas reservoirs. The model is then ready for the cluster computers, which split the complex processing into pieces, work on it concurrently, then reunite the pieces into the final product.

The resulting reservoir-scale image is a "whole other magnitude of resolution," says Blumenthal. Adds Blackwell: "You can start to discern whether it's a reservoir and contains hydrocarbons. You can interpret the type of reservoir and its porosity."

"This pulls together our key seismic technologies," he continues. "It takes tremendous resources, but as our computing capability gets faster and cheaper, we'll use it more until it becomes routine." —Nancy Boas



By Ashok Krishna



## Vantage Point \*

### CLEAN FUELS

Reflecting on a legacy of innovation, Ashok Krishna shares his optimism for the future of fuels

In India, lower-sulfur diesel made by refiners using Chevron-patented processes is reducing the kinds of emissions that were damaging the Taj Mahal, one of the country's greatest monuments. Chevron licenses its proprietary hydroprocessing technologies in more than 40 percent of the world's refineries in dozens of countries.

As global energy demand grows, so does the demand for cleaner, more efficient fuels. Chevron is seeking new technologies to propel the vehicles of tomorrow. In driving those technologies forward, we look to both our past legacy of refining innovation and to a future in which we challenge even our own traditions of fuels manufacturing.

With 19 wholly owned or joint-venture refineries in 14 countries, Chevron today has more than 2.2 million barrels per

day of equity processing capacity. This global network continues to move toward greater efficiency and productivity through increased automation, greater use of sensors to improve reliability and safety, and improvements in key processes, such as fluid catalytic cracking and alkylation.

Our company has a particular advantage: hydroprocessing. Combining temperature, high pressure, hydrogen and catalysis, hydroprocessing removes



## \* Vantage Point

impurities such as sulfur, metals and nitrogen from crude oil. The resultant cleaner-burning fuels meet increasingly more stringent air-pollution targets worldwide. The technology can help refiners handle more difficult kinds of crudes and get more clean fuel from each barrel of oil feedstock.

Innovations in this area began over 50 years ago, when our predecessor, Standard Oil Co. of California, sought better ways to process the heavier, nitrogen-rich crude oils found in its home state. Today, Chevron uses and markets a line of hydroprocessing-based technologies, including Isocracking® (to produce premium diesels), Isotreating™ (to clean up gas oils, residuum and products such as diesel fuel) and Isodewaxing® (for making next-generation lubricant base oils).

Chevron licenses its proprietary hydroprocessing technologies in more

than 40 percent of the world's refineries in dozens of countries, including China, Russia and the United States. In many parts of the world, this is contributing to cleaner air. For example, in my homeland, India, lower-sulfur diesel made by refiners using Chevron-patented processes is reducing the kinds of emissions that were damaging one of the country's greatest monuments, the Taj Mahal.

A strong hydroprocessing heritage also sets the stage for competitive advantage in new generations of clean-fuel technologies. For example, our gas-to-liquids joint venture with Sasol Ltd. combines our hydroprocessing upgrading and finishing technologies with Sasol's front-end technology to make superclean, synthetic diesel from natural gas (see article on Page 10).

In 25 years, about 40 percent of the world's hydrocarbon energy will come from such nonconventional resources as

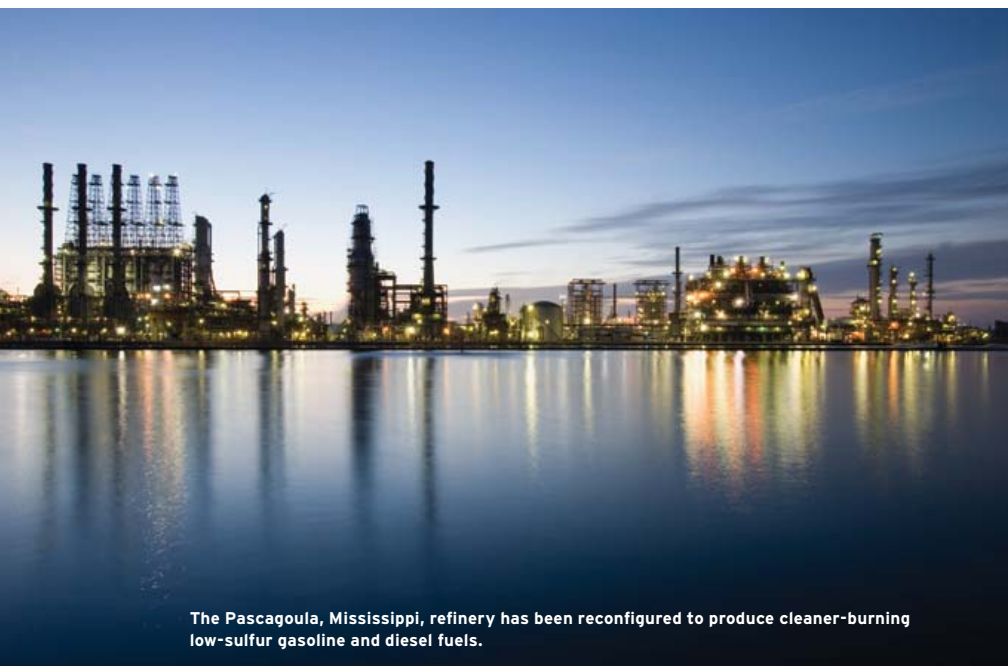
these and heavy oil. At the same time, the world is shifting toward cleaner, more efficient vehicle technologies. At our Richmond Technology Center in California, researchers are redefining traditional oil and gas techniques to meet these needs. By rearranging bundles of common molecular building blocks—carbon, methane, oxygen, nitrogen, hydrogen and others—the team is finding ways to craft fuels with superior performance characteristics. They call this “managing molecules.”

The team is exploring these concepts in partnership with General Electric, the U.S. Department of Defense, Sandia National Laboratories and the Clean Diesel IV Consortium.

The scientists and engineers are drawing not only on downstream expertise in refining but also looking to the upstream (exploration and production) end of the energy value chain for processes that will help transform more of the world's heavy oil in order to meet a bigger share of burgeoning world energy demand.

Will refining's future be as extraordinary as its past? Better products, safer operations, improved performance and growth are all within sight. Prospects for steering technology toward competitive advantage remain as bright as ever, and Chevron is determined to stay in the driver's seat.

*Ashok Krishna is general manager of technology for Chevron Global Refining and a 29-year veteran of the refining industry. He holds a master's degree and doctorate in chemical engineering and a master's in business administration.*



The Pascagoula, Mississippi, refinery has been reconfigured to produce cleaner-burning low-sulfur gasoline and diesel fuels.



## ROCK STARS

A university partnership prepares students to become peak performers in the energy industry

Chevron employees (from left) Hathaiporn Samorn, Reginald Onyirioha and Olusola Bakare get the academic view as well as practical experience through the CoRE program at the Colorado School of Mines. Here they explore the impressive geology surrounding the campus.

Hathaiporn Samorn, a Chevron employee from Thailand, gazes out at the Table Mountains, the easterly backdrop of the Colorado School of Mines (CSM) in the United States, where she is studying for a master's degree in geology.

"That's volcanic rock," she says, motioning toward the dramatic cliffs that rise from the lower slopes. "In my home country, it's uncommon to step outside and see outcrops like these," she adds, explaining how Colorado and

adjoining states provide a textbook of above-ground formations for geoscientists to study in order to better understand analogous terrain below the surface.

That's one of the reasons Samorn is so excited about being in Golden, Colorado. At the top of the list, though, is being one of the employees Chevron selected to enroll in its Center of Research Excellence (CoRE) in Subsurface Geology at the university.

CoRE provides students the ultimate learning opportunity: courses at a top-notch U.S. university and supplemental tutelage, mentoring and experience with a team of Chevron experts and university researchers. Using state-of-the-art tools and resources supplied by the company, the students apply their studies in a way that makes their projects and assignments even more meaningful.

Olusola Bakare, also a student in the CSM program, marvels at how quickly he



## \* Next Generation

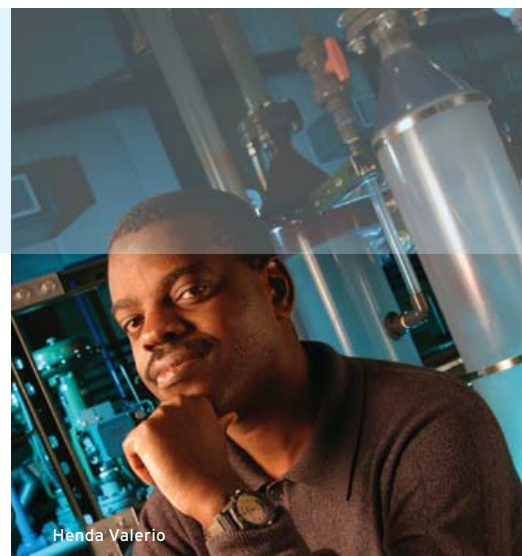
receives seismic data from the company's operations in his homeland, Nigeria, to use in developing his master's thesis on the geology of depositional processes in the Nigeria deep water. "My research is an integral part of the CoRE research, which is also focused on deep water," says Bakare. In addition to funding the CoRE facility and the students' education, Chevron collaborates with the university on various research projects.

In 2000, the company established its first CoRE at the University of Tulsa, in Oklahoma, to focus on crude oil and natural gas production systems. Three

years later, the University of Southern California (USC) became home to the second CoRE. With the interactive smart oil field technology as its focus (see Page 14 for more on i-field), the USC CoRE is exploring long-distance learning as a means to maximize student participation. The CSM CoRE is Chevron's newest, launched in October 2003.

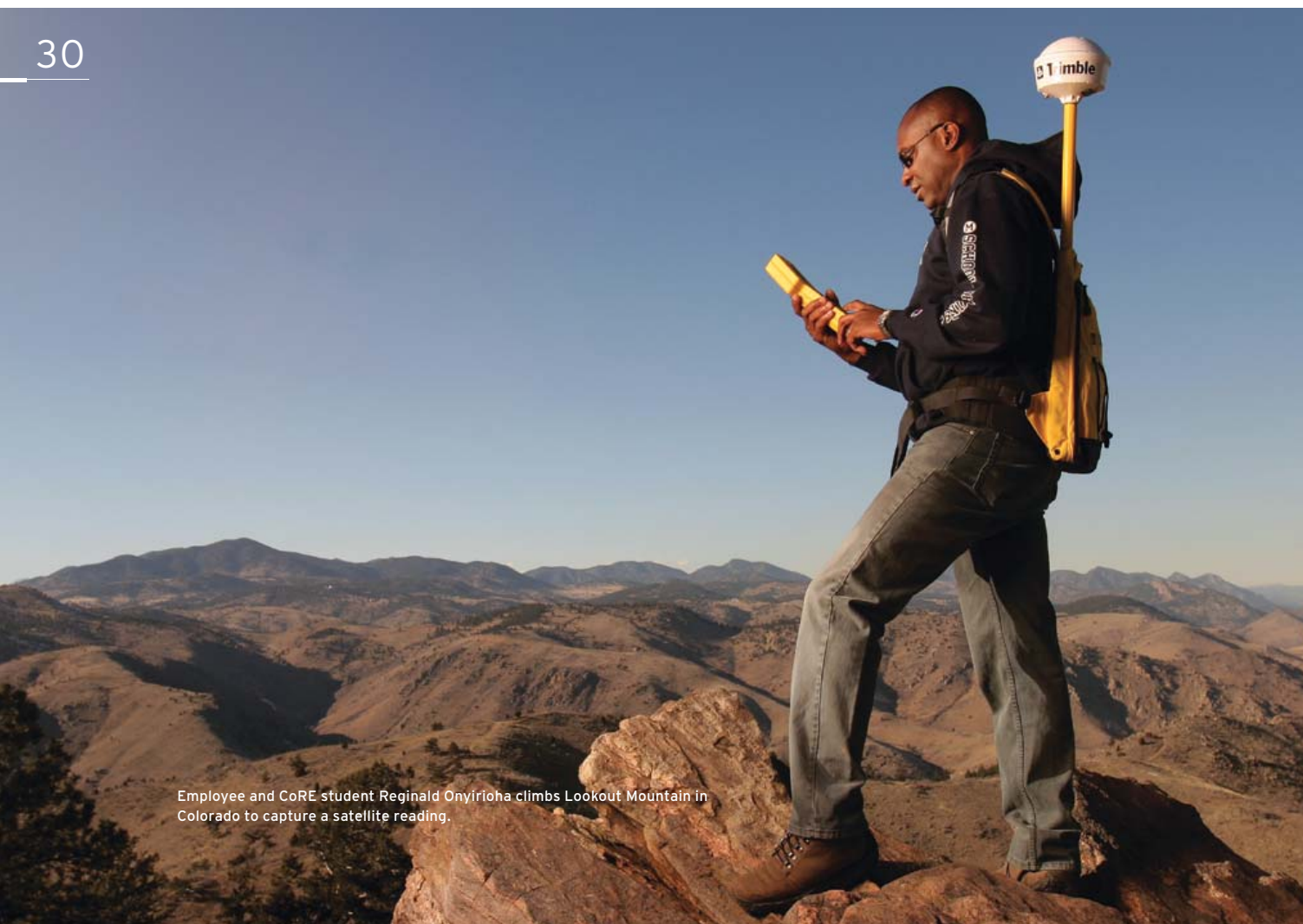
Says Erik Davidsen, who manages the CSM program for Chevron, "Our students are real standouts; they excel in their courses and are great representatives of the company's talent pool."

—Renée Silveira



Henda Valerio

Chevron's Henda Valerio graduated with a bachelor's degree in petroleum engineering from the University of Tulsa, in Oklahoma, in December 2003. While in the CoRE program there, Valerio was able to link his academic learning to his work experience in a way that allowed him to hit the ground running when he got back to work in his homeland, Angola. "By the time I had returned to my country, I had already studied and examined many of the technical issues we face in day-to-day operations," he says.



Employee and CoRE student Reginald Onyirioha climbs Lookout Mountain in Colorado to capture a satellite reading.







## GOOD FELLOWS The company's top scientists and engineers, known as the Chevron Fellows, play a key role in mentoring a new generation of employees

Back in 1984, Chevron chemist Steve Miller had a strong hunch that wax molecules in base oil—used as engine lubricant—could be reconfigured using a special catalyst to yield even better molecular struc-

minimizing the production of lower-value byproducts. When he looked at the results of the first experiment, he thought he had failed. "The yield of base oil was lower than I was hoping for," Miller says.

But the quality of the oil was surprisingly high, and that kept Miller intent on improving the technology. In 1993, the proprietary catalytic process was commercialized and today remains an industry standard for base oil processing.

Miller's contributions to the field of catalysis are recognized industrywide. He has worked for Chevron 28 years and is a member of a group of honored technology masters called the Chevron Fellows.

Not just an honorary society, the Fellows help the company shape its technology choices and direction, and they also play an important role in passing on their knowledge and nurturing the skills of the next generation.

Although Miller doesn't have time to do the hands-on experiments himself anymore, he's still in discovery mode. With more than 120 patents to his credit, he continues to use his expertise and experience to advance the company's technical competency. He knows a lot about perseverance and risk taking—"some failure is helpful because it can lead to even greater insights"—and he knows how to "connect ideas to the business" so that they get support and funding.

"You need to stay on top of what's happening in science and technology and in what direction the industry is going," he says.

Fuels expert Lew Gibbs, also a Fellow and, like Miller, based in Richmond, California, agrees. With Chevron for 47 years, Gibbs is an internationally recognized authority on gasoline and gasoline-oxygenate blends. He keeps his finger on the pulse of the fuels business by being active in industry

groups, professional technical societies as well as collaborative research projects.

Gibbs authors technical papers and conducts peer reviews on papers written by other researchers. He participates in ASTM International, a voluntary organization that develops technical standards for materials, products, systems and services. Gibbs chairs its committee on gasoline and gasoline-oxygenate blends. He also heads a technical committee for SAE International, the premier society that's dedicated to advancing mobility engineering worldwide.

Among their responsibilities as Fellows, Gibbs and Miller participate in the Mentoring Excellence in Technology program, which helps high-potential employees in the fields of technology and science develop their business sense so they can flourish in their endeavors—just as these fellows have.

—Renée Silveira

Respected industry experts Steve Miller (left) and Lew Gibbs.



## BIOFUELS: STRATEGIES FOR A GROWING MARKET

A new Chevron business unit's initiatives include turning soybeans and plant wastes into efficient energy sources

Economic, environmental and energy security concerns are increasingly driving motorists toward the use of biofuels.

As part of its strategy to invest in renewable energy technologies, Chevron has formed a biofuels business unit to advance technology and pursue commercial opportunities related to the production and distribution of ethanol and biodiesel.

A key initial investment is in one of the first large-scale biodiesel plants in the United States. Planned initial production is 20 million gallons per year, equivalent to almost 27 percent of the total U.S. biodiesel production of 75 million gallons in 2005. The facility will have the potential to produce 100 million gallons per year of this clean-burning, renewable fuel.

Houston, Texas-based Galveston Bay Biodiesel LP is constructing the biodiesel production and distribution

facility in Galveston, scheduled for completion by the end of 2006. It will produce biodiesel from soybeans and other renewable feedstocks. The business has the option to sell either pure biodiesel or biodiesel blended with off-road or on-road diesel in marine, commercial, trucking and industrial markets in the Galveston and Houston metropolitan areas.

In a separate initiative, Chevron has formed a strategic research alliance with the Georgia Institute of Technology, in the United States, to pursue production of cellulosic ethanol—derived from plant wastes such as straw—and reforming technologies that could make alternative energy sources, such as hydrogen and ethanol, more efficient and economical.

Earlier this year, Chevron announced that it has joined a demonstration program to learn more

about ethanol as a potential automotive fuel. In a collaborative project with the state of California, General Motors and Pacific Ethanol, the company will evaluate E85, a blend of 85 percent ethyl alcohol and 15 percent gasoline. The project will study performance, efficiency and environmental issues over a one-year period using California-formulated E85.







A hybrid fuel cell bus fills up at Chevron's hydrogen station in Oakland, California. Chevron is participating in a U.S. Department of Energy program to demonstrate safe, practical hydrogen technologies in real-world settings.

## TAKE THE BUS ON THE ROAD TO HYDROGEN

Chevron station supplies the fuel—and a future of transportation possibilities

33

Chevron's second hydrogen energy station opened at the Alameda-Contra Costa (AC) Transit Operations Center in Oakland, California, this year. The station produces, purifies, compresses, stores and dispenses hydrogen gas—all onsite—to supply three demonstration buses.

Powered by UTC Power's hybrid electric-hydrogen fuel cell technology, the 40-foot (12-m) buses were developed for AC Transit by Van Hool and ISE Corp. They are among the most advanced vehicles of their type in the world. Chevron's energy station not only fuels the buses, but it also supplies enough hydrogen to fuel the 10 Hyundai FCEVs (fuel cell electric vehicles) in AC Transit's demonstration fleet.

The March 13 opening featured a video broadcast of California Governor Arnold Schwarzenegger noting the significance of the project in a state "committed to clean air." This event followed the unveiling of a similar facility in Chino, California, in 2005, another Chevron partnership with Hyundai and UTC Power.

"It's hard to top the excitement of our first hydrogen station in Southern California last year," says Rick Zalesky, vice president of Chevron Hydrogen Co., "but this project involves public transit vehicles in regular service, meaning that the average person will experience fuel cell technology when riding the demonstration buses. Now that is really

exciting." Up to four more stations are planned to be built by year-end 2008.

Chevron is the only energy company leading a project for the U.S. Department of Energy to demonstrate onsite natural gas reformation. Rather than transporting hydrogen to the station, Chevron uses onsite processing equipment to convert natural gas—delivered via the same underground utility pipe infrastructure that supplies homes—and water into hydrogen and carbon dioxide. The process, which requires heat and catalysis, generates no smog-forming nitrogen oxides or particulates. The vehicles' onboard fuel cells use the hydrogen to generate electricity, with water as the only byproduct.

# IN CONVERSATION WITH

**Next\*:** With the world looking to new technology to solve its energy needs, how is Chevron responding?

**Don Paul:** Chevron has a world-class lineup of opportunities, so we're investing across the board. We're improving technologies to help us get more out of known crude oil and natural gas fields in places such as California and to find new fields

**Next\*:** How does Chevron manage technology, and what's the advantage to partners and investors?

**Paul:** Our approach is really quite different. We manage our upstream, downstream and information technology [IT] groups as one organization to drive cross-fertilization and integration opportunities. And we leverage our R&D

management with companies such as Microsoft, Halliburton and Schlumberger. And our gas-to-liquids business is based in a technology joint venture with Sasol, the world GTL leader.

**Next\*:** How do you leverage R&D with governments?

**Paul:** The U.S. government is the world's largest R&D funder, and Chevron manages some \$250 million in federal energy R&D, including a hydrogen commercialization venture with the Department of Energy and an industry consortium to protect energy infrastructure with the Department of Homeland Security. In these projects, we're the aggregators and orchestrators, and our partners appreciate us because we help establish the platforms necessary to get new technologies commercialized. I believe our collaborative approach has created a new class of opportunities for Chevron.

**Next\*:** How does Chevron work with universities?

**Paul:** We fund many R&D relationships, with our strongest focus on our Centers of Research Excellence at the University of Tulsa, in Oklahoma, the Colorado School

## Chevron's chief technology officer discusses the company's leveraged approach to R&D, managing molecules, information factories and more

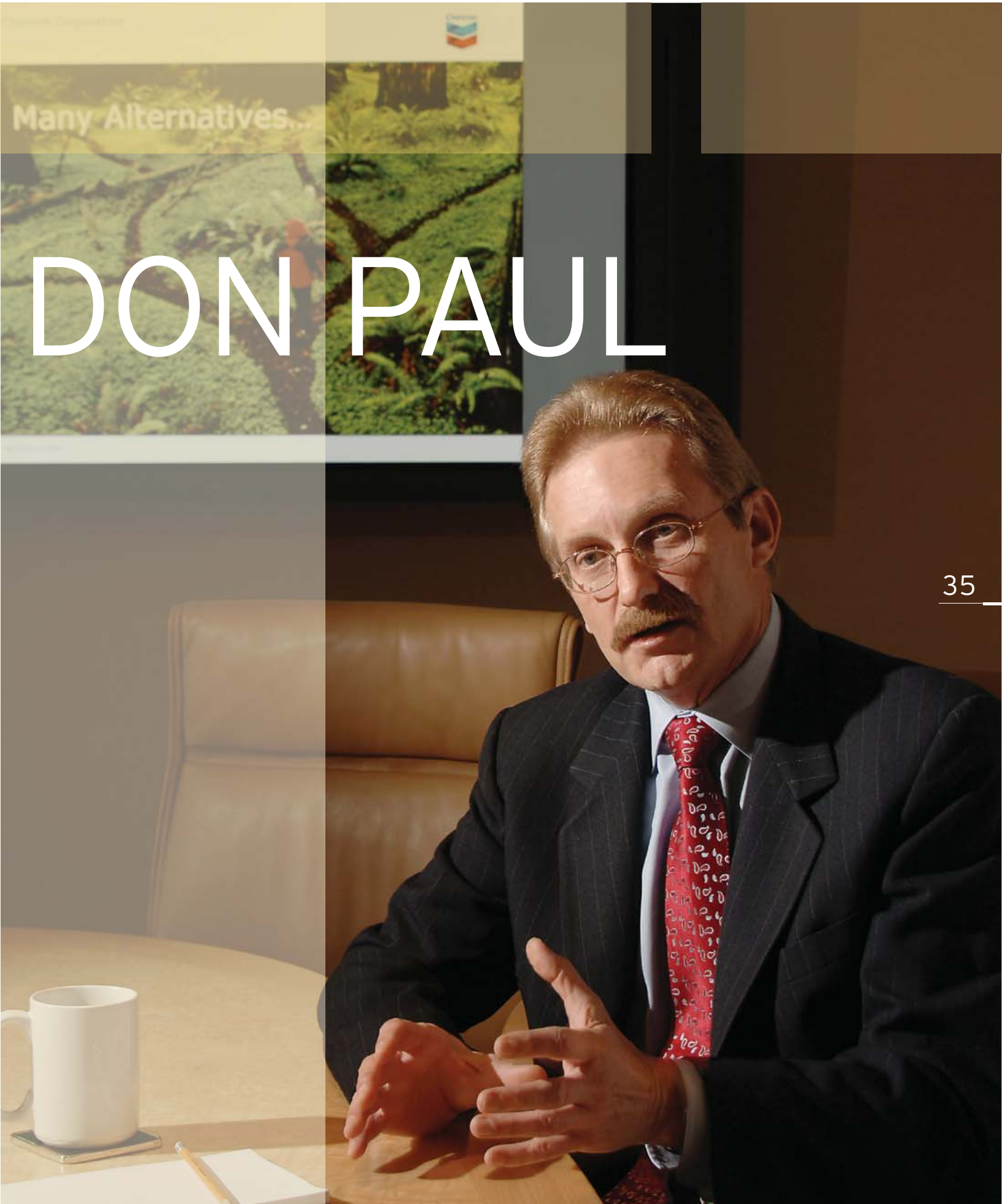
in remote places, for example, deepwater Nigeria. We're linking technologies from the upstream and downstream ends of the value chain to tap difficult resources, like extra-heavy oil from the Athabasca tar sands. We're expanding transportation fuel supplies with gas-to-liquids [GTL] and biofuel technology. And we're investing in research and development [R&D] to diversify world energy feedstocks and energy sources: shale, solar, hydrogen and others.

through partnerships that are more like joint ventures, sharing costs and ownership of intellectual property. We figure we're getting the impact of around \$4 for every \$1 we invest in external R&D, which is a 1.6 times uplift on our total portfolio.

**Next\*:** What are some examples of leveraged R&D?

**Paul:** We have close partnerships in oil field automation and real-time drilling





Many Alternatives...

# DON PAUL

of Mines and the University of Southern California [USC].

**Next\*:** What are your recruiting and hiring priorities these days?

**Paul:** We're especially interested in people with hybrid skills—half earth scientist or engineer, half information technologist—people who can function in the interface and see the future. This is one reason our Center for Interactive Smart Oil Field Technologies at USC offers a new graduate degree that's part energy and part IT, with other key disciplines. Also, the whole industry needs more chemical engineers, process engineers and materials scientists to work in molecular conversion and synthesis.



**Next\*:** Conversion and synthesis—are these the technologies you had in mind when you recently described Chevron's business as “managing molecules”?

**Paul:** Throughout our history, we've converted raw resources into fuels by distillation and, more recently,

catalysis—engineering chemical reactions on a molecular scale—which I view as the nanotechnology of the energy industry. We'll be doing a lot more of this molecular alchemy. The GTL business uses catalysis to synthesize a superclean diesel fuel by converting natural gas. Our upgrading projects for heavy oil rely on catalysis, as does making hydrogen from natural gas in fuel cells. Conversion and synthesis are key to diversifying the world's energy mix.

**Next\*:** Much of the company's success depends on partnering with oil-producing countries. What does Chevron bring to the table?

**Paul:** In the past, national oil companies wanted us for our financing, project management, technology transfer and training. All of those are important, but to compete today, we're also bringing next-generation tools most competitors can't match, such as our new Intersect reservoir simulator and conversion technologies that can broaden a partner's base of energy businesses. Our GTL project in Nigeria is a good example. More important, we bring world-class technology-integration skills.

**Next\*:** Explain integration.

**Paul:** Often what we do involves hundreds of individual technical components, and integrating them is enormously complex. Developing oil and gas fields, for example, requires expertise in what we call the sub-surface work flow: mapping a reservoir, characterizing it, computer simulating the development of wells and facilities,

managing precision drilling, and so on. We have to integrate complex software applications and very large data flows. From planning to construction to operations, oil fields today are like information factories. Our ability to integrate is an organizational competency of tremendous value to partners.

We're working on the third generation of our global, digital infrastructure, Global Information Link [GIL]. GIL gave us standardized, worldwide connectivity. GIL 3 is about managing information, linking pieces and parts—whatever their form and however dynamic they might be. The next IT wave for our industry is a convergence of sensors, measurements, integration and optimization, all globally enabled by systems like GIL. We view it as another kind of technology advantage countries can get when choosing to work with Chevron.

**Next\*:** What would you say to people who are worried we're running out of energy resources?

**Paul:** No one doubts that conventional oil production eventually is going to peak. Some say 2010, others 2030. How fast we can fill the gap with other resources, such as heavy oil and undeveloped natural gas, remains to be seen. But we won't run out of energy molecules, so we won't run out of fuel. As the resource base shifts, R&D investment—for example, in unconventional feedstocks and in commercializing alternative energy sources—will follow opportunity, as it always has. Just when the world thinks it is running out of something, science and technology make something else work.



# A 5% reduction in global energy use would be enough to power Australia, Mexico, and the entire UK.

So what are we waiting for?

Because of surging economies in the developing world and continued growth among the industrialized nations, global energy use is climbing. As a result, supplies are tight. Prices are rising. And energy users are calling for viable alternatives.

The good news is we've got a huge source of alternative energy all around us. It's called conservation, and it's the lowest cost new source of energy we have at hand. A reduction of just 5% of global energy use would save us the equivalent of over 10 million barrels of oil a day. Clearly, saving energy is like finding it. So how do we do it?

For developed and emerging economies alike, incorporating energy efficient technology into new construction could reduce consumption by 40%. Governments and businesses must reduce their own energy use and promote conservation to their citizens and employees. Further improvements in fuel efficiency will play a crucial role, too. And the average person wields incredible power when it comes to conserving energy, from driving slower to switching to more efficient home appliances.

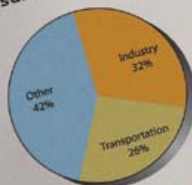
Of course, not only does using less energy mean there's more fuel to go around, it also means fewer greenhouse gas emissions. The fact is, if everyone began conserving today, we'd see results immediately. We've taken some of the steps needed to get started but we need your help to get the rest of the way.



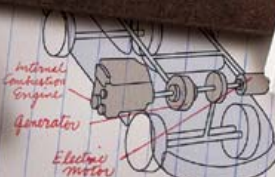
Replacing just one incandescent light bulb with a compact fluorescent lamp would save 500 pounds of coal and over a 1/2 ton of CO<sub>2</sub> emissions

CHEVRON is a registered trademark of Chevron Corporation. The CHEVRON HALLMARK and HUMAN ENERGY are trademarks of Chevron Corporation. ©2005 Chevron Corporation. All rights reserved.

## Delivered Energy Consumption by Sector



will you join us.com



## ⚠️ Chevron Steps Taken:

- Since 1992, Chevron has improved energy efficiency by 24%
- We use cogeneration technology at our refineries to produce additional electricity from otherwise wasted energy

## Saving other people's energy:

- Chevron Energy Solutions is a separate, proven business dedicated to energy efficiency. Success stories include:
  - Improvements that will lower a regional postal service's electricity spending by 46%
  - Helping the U.S. government save taxpayers \$151 million while reducing greenhouse gas emissions by an expected 1.5 million tons



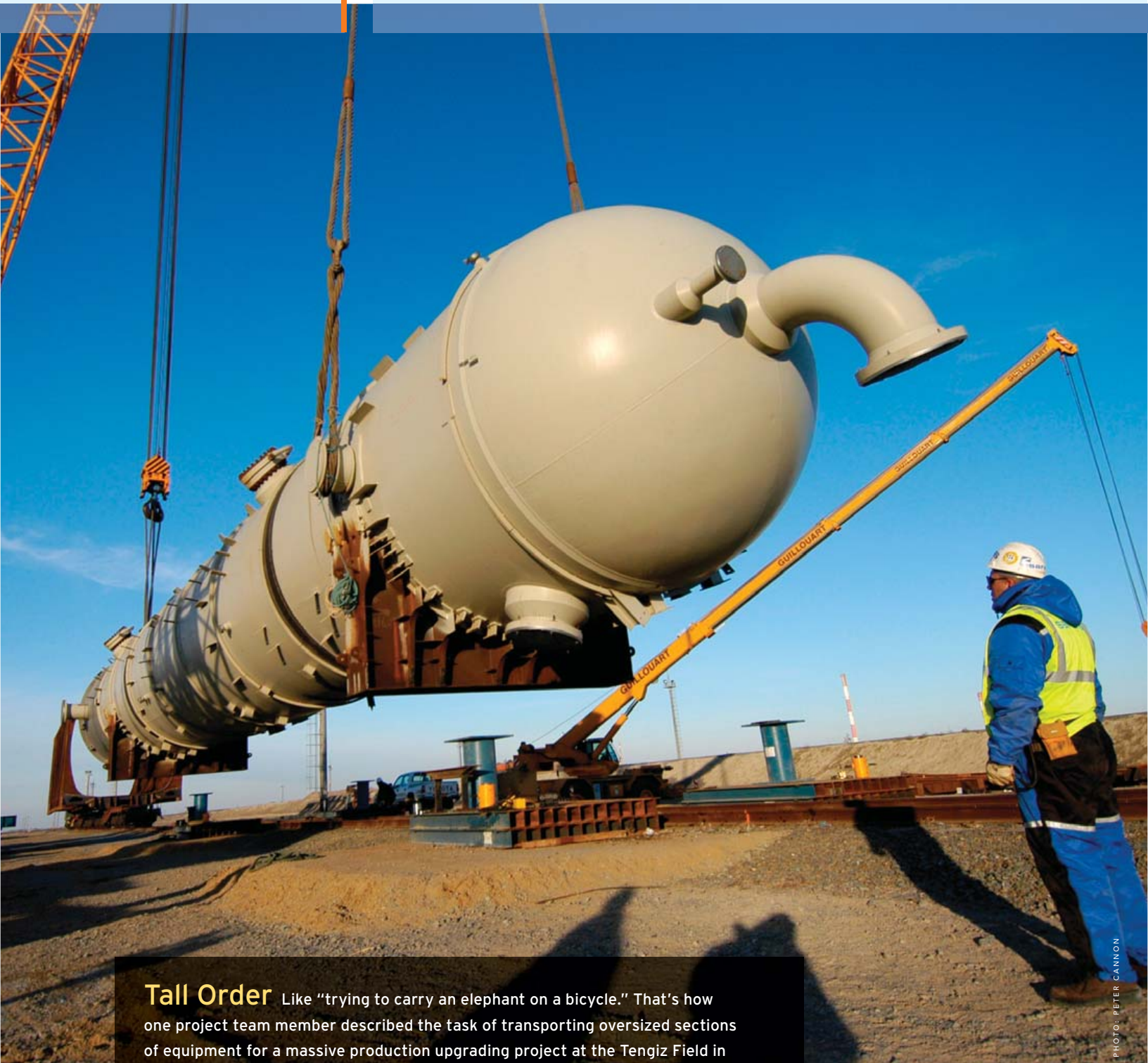
Human energy™

Cautionary Statement Relevant to Forward-Looking Information for the Purpose of "Safe Harbor" Provisions of the Private Securities Litigation Reform Act of 1995: This publication of Chevron Corporation contains forward-looking statements relating to Chevron's operations that are based on management's current expectations, estimates and projections about the petroleum, chemicals and other energy-related industries. Words such as "anticipates," "expects," "intends," "plans," "targets," "projects," "believes," "seeks," "estimates" and similar expressions are intended to identify such forward-looking statements. These statements are not guarantees of future performance and are subject to certain risks, uncertainties and other factors, some of which are beyond our control and are difficult to predict. Therefore, actual outcomes and results may differ materially from what is expressed or forecasted in such forward-looking statements. You should not place undue reliance on these forward-looking statements, which speak only as of the date of this publication. Unless legally required, Chevron undertakes no obligation to update publicly any forward-looking statements, whether as a result of new information, future events or otherwise.

U.S. Securities and Exchange Commission (SEC) rules permit oil and gas companies to disclose only proved reserves in their filings with the SEC. Certain terms—such as "probable," "possible," "potential" and "recoverable" in reference to "resources," "gas resources" and "crude oil in place"—and others used in this publication may not be permitted to be included in documents filed with the SEC. U.S. investors should refer to disclosures in Chevron's Annual Report on Form 10-K for the year ended Dec. 31, 2005.



## \* What's Next



**Tall Order** Like “trying to carry an elephant on a bicycle.” That’s how one project team member described the task of transporting oversized sections of equipment for a massive production upgrading project at the Tengiz Field in Kazakhstan. In some cases, loads 30 feet (9 m) wide had to be balanced on a 5-foot-wide (1.5-m) rail track. Here, sections of a propane storage tank make their way from Kazakhstan’s port of Aktau to the field. The Tengiz Field is operated by Tengizchevroil, a joint venture in which Chevron has a 50 percent interest. Look for a full report on the project in a future issue of *Next*.\*

PHOTO: PETER CANNON