

GAME CHANGER:

In an **exclusive interview**, Royal Dutch Shell's CTO talks about innovation, technology trends and R&D, including **a successful Alberta test of its in-situ upgrading process** — a Holy Grail of oilpatch technology in which upstream and downstream would converge.

By Pat Roche

Upstream Under- ground Downstream upgrading

At a time when Royal Dutch Shell plc has revved up its research engines, doubling its R&D spending to \$1.2 billion (US) last year from about \$600 million in 2005, funding of its potentially game-changing in-situ upgrading process (IUP) appears to be paying off.

On a recent visit to Calgary, Jan van der Eijk, Shell's chief technology officer, pronounced the company's IUP test at Peace River in northwest Alberta as "very successful."

In what could lead to one of the most revolutionary innovations in the history of the oil and gas industry, Shell has been testing a way to upgrade bitumen in the reservoir for more than two years. Electric heaters raise the sub-surface temperature to the point where the reservoir, in effect, acts as a refinery.

"The product that you produce is almost water white, and it is as mobile as water," says van der Eijk.

As happens in a refinery, the lighter products are boiled off, leaving the heavier components behind in the reservoir. The upgraded oil can be further refined into products such as gasoline and jet fuel.

"The product is really impressive..." the CTO enthuses. "It is actually quite exciting."

Evidence of Shell's increased emphasis on research is its ramped-up investment of recent years. Van der Eijk says the company's R&D spending in the past two years exceeds that of the other supermajors by hundreds of millions of dollars.

While the pursuit of avant-garde technologies will always be part of the R&D investment, technology development isn't always about developing new technologies, according to Shell. A growing trend in North America is the increased emphasis on resources such as tight gas and oilsands. These plays are more about economics than geoscience: we know the resource is there, but how can we develop it economically?

In an exclusive interview with *New Technology Magazine*, van der Eijk was asked how this trend is reflected in the supermajor's technology focus.

"Shell is very much of the conviction that we will win the competitive battle [by] technology differentiation. And technology differentiation is not just the creation of proprietary technology to convert hydrocarbons into products and things like that," van der Eijk says.

"But it is also very much around excellence in the operation of technical facilities, and also integrating technologies other people developed. And ... for some areas like tight gas it's not so much about coming up with a spectacular new idea [on] how you could unlock these resources, but it is about getting to a high degree of industrialization and having operational excellence in the way you drill the wells and [create] the fractures, that you are doing this in an automated, disciplined manner."

Within Shell, he says, the focus isn't only on attention-grabbing new products.

"Innovation does not only come from stuff that you could protect by patents, but it also has to do with how well you're bringing in new working practices and [can] drive costs out of your system."

By doing this well, he says, a company can become a leading player in a field without necessarily having many patents. By continuously improving its technological practices and driving down costs, a company can develop a sustainable cost advantage. Van der Eijk believes this applies "very much" to extracting resources such as tight gas, but also to pursuits such as enhanced oil recovery.

In other words some of the industry's most important technological advances happen in the field, not in the lab, and are the result of gradual improvements over time, not spectacular breakthroughs.

Holy Grail

Should it work on a commercial scale, Shell's in-situ upgrading technology, however, would represent a triumphant breakthrough. For years Shell has been experimenting with electric heaters at its ongoing Mahogany oil shale experiment in Colorado, but the Peace River-area test is the first time they've been used to upgrade oil. (Oil shale is rock containing kerogen, the precursor of crude oil. Oil shale yields oil at high temperatures.)

Located on well pads 50 and 51 (CADOT 7-2-85-18 W5M), the pilot uses 18 electric-heater wells, three oil producer wells and eight observation wells. (Shell's Peace River complex is 40 kilometres northeast of the town of Peace River.) So far, 100,000 barrels (bbls) of black, semisolid Peace River tar have been converted to high-quality light oil (30 to 49 degrees API gravity).

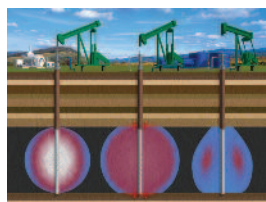
It's not surprising that the supermajor would test such technology at Peace River, where it is sitting on an estimated seven billion bbls of in-place bitumen. Nor is it surprising that the in-situ upgrading pilot went largely unnoticed when it was built more than two years ago. Shell has tested many production processes at Peace River since it discovered the sandstone reservoir in 1951. The cyclic steam project is one of Canada's oldest thermal bitumen developments, and is currently preparing for significant growth. (Shell also operates the Athabasca Oil Sands Project, a huge mining megaproject, which is also gearing up for a major expansion.)

But what didn't go unnoticed was when Shell plunked down about half a billion dollars more than two years ago for rights to the Grosmont, a bitumen-rich carbonate formation in northern Alberta. Why, it was asked, would anyone pay so much for a resource that has never yielded commercial production (*New Technology Magazine*, Summer 2006)?

The curious may find at least part of the answer in a filing now before Alberta's Energy Resources Conservation Board. On the heels of its successful Peace River pilot, Shell filed a regulatory application late last year to test its IUP in the bitumen carbonates on Townships 90

UNDERGOING A CONVERSION

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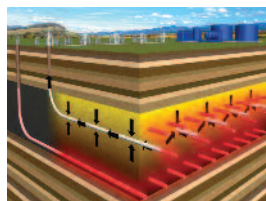
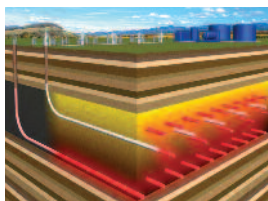
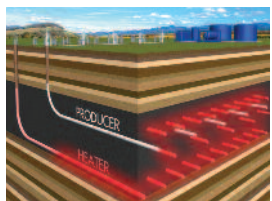
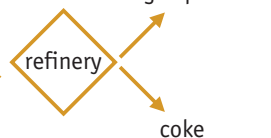


produce heavy oil

Standard In-Situ Recovery



combine with diluent



produce lighter oil

coke remains in subsurface

Shell In-Situ Upgrading Process (IUP)



combine with diluent



- more oil recovered
- higher quality product
- coke left underground

and 91, Range 23, West of the 4th Meridian. (That is on Shell's Grosmont lease area about 120 kilometres north of Wabasca.)

The Grosmont pilot will use the same type of electric heaters deployed at Peace River and in the Colorado oil shales. The purpose of the Grosmont pilot is to assess the composition of the upgraded product, determine recovery efficiency, identify geomechanical issues and evaluate the heaters for a potential commercial development. Once it gets the regulatory nod, Shell expects the pilot will run for several years.

If this carbonate-contained bitumen can be upgraded in the reservoir and a sizable percentage recovered, the prize is potentially billions of bbls of light oil.

So how much of the oil in place did the Peace River pilot produce? "Just from that plot of land and the hydrocarbons present there, the 100,000 bbls represents a very significant recovery," van der Eijk says. So far, Shell hasn't published the recovery factor. "But it is significant, I can tell you. It's more than what you typically could achieve," the CTO says, adding: "In that sense it is a significant success."

Before starting the pilot, Shell used models to predict temperature and pressure development. "I'm really impressed personally by the ability of the models to predict what actually happened," van der Eijk says.

However, the Grosmont will likely be a tougher nut to crack. Though pilots were run in the 1980s (New Technology Magazine, Summer 2006), no one has so far achieved commercial production of bitumen from the carbonates.

Depending on the results of its Grosmont pilot, Shell will decide whether to proceed with a commercial development of its vast bitumen carbonate deposits. Van der Eijk says the company could be in a position to make that decision by the middle of the next decade. He notes the timeframe is typical for such innovations. "The major technological developments in the oil industry — they take time."

And refining in the reservoir would indeed be a major technological development. Bitumen upgrading is now done inside specially built steel vessels where temperatures, pressures and other conditions can be strictly controlled. Even so, things go wrong, resulting in costly production outages. So what are the chances of achieving success in the reservoir where far less control is possible?

Van der Eijk — a chemist who began his career as a research scientist in Shell's downstream business — appears to enjoy the question.

"In a refinery," he explains, "you need to have a certain throughput through a vessel. And that drives you to a certain reaction rate; otherwise, you just don't have enough productivity." But in the subsurface, the reservoir serves as a gigantic vessel. "And in that sense you can allow much lower reaction rates. The vessel is much larger and you can let it go for a year rather than a minute throughput [in a refinery]."

So while the reservoir may not allow the kind of strictly controlled conditions achievable in a

refinery, it is also more forgiving because of the size of the "vessel" and the long residency times.

Nonetheless, as a recovery process, in-situ upgrading is still far more ambitious than any of the thermal techniques that have achieved commercial success. Those processes — such as cyclic steam stimulation (CSS) and steam-assisted gravity drainage (SAGD) — simply use steam to improve the bitumen's viscosity.

Strictly from a thermal standpoint, CSS and SAGD are comparable to melting butter in an oven — whereas in-situ upgrading means chemically cracking the hydrocarbon. In fact, van der Eijk says in-situ upgrading of bitumen isn't terribly different from the in-situ extraction of oil from oil shale. "In terms of temperature required, plus the reaction speed ... the speed with which the hydrocarbons are released is actually not too different."

Refining in the reservoir — a Holy Grail of oilpatch technology in which the upstream and downstream would converge — won't happen overnight. But with more than a century of innovation under its belt, Shell is up to the challenge. For example, the venerable Anglo-Dutch giant says it launched the world's first purpose-built, ocean-going tanker in 1892, revolutionizing oil product transport. At last count, Shell boasted 26,621 patents — 10,932 fully approved and 15,689 pending.



IN A WIDE-RANGING INTERVIEW, SHELL'S CTO TALKED ABOUT TECHNOLOGY TRENDS WITHIN ONE OF THE WORLD'S LARGEST COMPANIES:

JAN VAN DER EIJK

Job: chief technology officer,
Royal Dutch Shell

Employees: 30,000

Appointed: May 2006

Shell career: started in 1980 as a research scientist in the Amsterdam labs; promoted to various research and management posts, mostly in the chemicals group

Education: doctorate in physical organic chemistry from the State University of Utrecht in the Netherlands

Reason for Calgary visit: To help Shell's oilsands operations develop a five-year technology plan, and to gain a better personal understanding of the technological dimensions of the oilsands

WHY A CTO? Van der Eijk's title sounds more Silicon Valley than oilpatch. However, a few of the large oil and gas companies have appointed chief technology officers this decade. Asked about the position, van der Eijk offers a historical perspective. In the 1980s many oil companies had a central R&D organization with a leader whose job description was similar to that of a CTO. Then many companies moved to a more business-aligned R&D organization — for example, separate R&D segments for upstream, downstream and chemicals.

Now the job of a central R&D leader is returning, and van der Eijk believes it's driven by a few factors. "One is that technology is becoming very important for oil companies to grow and to maintain their licence to operate," he says. Another factor is the development of new technologies that don't fit within the industry's traditional businesses. Carbon capture and sequestration would be one example. Many new technologies transcend business boundaries. The gas-to-liquids process, for instance, has both an upstream and a downstream component.

Does the trend also reflect heightened awareness of R&D? Towards the end of the last century low commodity prices led to big cuts in R&D spending. Now, says van der Eijk, rising oil prices and greater demands for a reduced environmental footprint have led to an upswing in R&D spending.

STILL MAINLY AN OIL COMPANY? From an R&D standpoint, is Shell still mainly hydrocarbon focused? Is research into renewables just a sideline?

To the first question, van der Eijk says the company has a strategy of making more hydrocarbons available in an environmentally responsible manner. To the second question, he says a stated goal of the company is to have a "material" renewable energy business. He says Shell has "significant" wind power capacity and is looking at further expansion in North America. The company has a "growing" biofuels business (ethanol and biodiesel).

Van der Eijk won't say how much of Shell's R&D budget is for renewable and alternative energy, but he is adamant that the amount isn't trivial. "This is not a kind of a sideline where we spend maybe one per cent, one or two per cent [of the R&D budget] and it makes us look good. This is a serious business intent to develop a material renewable energy business and our R&D expenditures are in line with this. It is definitely not a sideline."

On the biofuels side, Shell is partnered with Ottawa-based Iogen Corporation, which built a small demonstration-scale plant to produce cellulose ethanol. Regular ethanol has come under fire lately for using human food such as corn and wheat as its feedstock. Cellulose ethanol is made from non-food raw materials such as straw and corn stalks, but

this requires extra processing, hence the need for more R&D.

Shell also has programs for “new energy crops,” van der Eijk says. “In particular, we’re focusing on the production of algae from which you can then extract oil [which], upon refining, ... can be used as biodiesel.”

But the company is also working on new ways to use fossil fuels.

One example is Shell’s proprietary gas-to-liquids (GTL) technology, which took 25 years to develop. (Various GTL processes — which convert natural gas to a clean-burning, low-carbon liquid — have been around for decades, but haven’t achieved widespread commercial adoption.) Shell is building what it terms the world’s largest GTL plant in the tiny Middle East nation of Qatar. Production is slated to start around 2010, rising to 140,000 bbls a day of GTL fuels and products. Shell also launched one of the world’s first commercial GTL plants at Bintulu, Malaysia, in 1993.

Another process that has been technically viable for many years but hasn’t achieved widespread adoption is coal gasification — extracting a low-carbon gas from coal. Shell says a 253-megawatt power plant using the

company’s coal gasification approach has operated in the Netherlands since 1994.

As well, the company has been working on an in-situ process to produce light oil from oil shale (kerogen-bearing rock) in Colorado for more than a quarter century (New Technology Magazine, Summer 2006).

TERTIARY OIL RECOVERY Shell was a pioneer in the injection of naturally-produced carbon dioxide to boost oil recovery in Texas in the 1970s. Shell exited that field long ago, but recently increased its global focus on tertiary oil recovery. “The whole industry is doing that now,” says van der Eijk. “I think that’s an important trend.”

In the Middle East nation of Oman, Shell is partnered with the Omani government to pilot a wide range of enhanced recovery techniques to get more oil out of mature fields. These include everything from the injection of steam and miscible gases to the use of detergents and polymer floods. Looking ahead, the company is investigating ways of using CO₂ captured from manmade sources for EOR.

ON PARTNERING In the past, if Shell wanted a

technology, it was developed in house and applied within the company. “I think that model is one that we somewhat need to modify,” says van der Eijk, “because I believe there are now so many entities outside the energy industry that are developing technology that is relevant to our industry that we need to find a way to tap into that knowledge base.”

Partnerships with Canadian universities are a good example of this trend toward collaborative technology development, he says. “This is one of the approaches I really like to encourage worldwide for the company.” And increasingly, Shell is partnering with technology startups, sometimes via contract and sometimes by taking an equity stake. A third group of companies with which Shell’s collaborative technology development occurs are the large engineering firms, whose expertise may, for example, be harnessed to develop a specific technology for ultra-deepwater projects.

But Shell continues to develop its own proprietary technologies and the goal is to integrate those with innovations achieved through external collaborations. “And that’s an area,” says van der Eijk, “where Shell really tries to push the boundaries and be basically the fastest and most effective integrator.” **ntm**