Digital fields help produce more oil

An important strategy to meet growing global oil demand is to increase oil production from existing fields, as new fields are becoming scarce. Oil companies are developing ‘digital fields’ to increase production. A combination of smart technologies and new workflows can also prove useful in more complex and remote areas, such as unmanned deepwater reservoirs.

by Annemieke van Roekel

The year 2014 will be a critical year with respect to global oil demand, as demand will probably surpass production then. There will not be enough new oil fields, or new fields will be increasingly located in politically unstable regions, so that oil production will become more complex, e.g. at deep sea locations, in areas where the underground geological structure is complicated, or in polar climates.

To win more oil from existing fields, the oil industry has been developing enhanced oil recovery methods (EOR or IOR, see box) for the past 50 years, and the process continues up to this day. Recent estimates by the International Energy Agency (IEA) point to a potential of 300 billion barrels by applying EOR - equal to ten years of global oil consumption - and so far this figure hasn’t changed, an IEA-spokeswoman says. To put this in perspective: total resources from oil shale and tar sands equal 2,000 billion barrels.

Norway, the world’s fifth oil exporter, has improved its oil recovery rates from 32% in the 90s to 47% at present. This is very high in comparison with the average global rate of 35%. ‘High recovery has been realized mainly in the large fields on the Norwegian Continental Shelf, such as the Statfjord and Ekofisk fields,’ explains spokesman and geoscientist Johannes Kjøde of the Norwegian Petroleum Directorate (NPD). ‘Large fields have long-term perspectives with more options for redevelopment’. The basic tool for improved oil recovery in Norway is pressure maintenance in the reservoir. High pressure is realized by injecting water or gas, or a combination of both. Kjøde: ‘We have also improved drilling technologies. Through horizontal drilling and multi-branch drilling the reservoir can be reached from all sides and more oil can be extracted. The Troll field has applied the most innovative drilling technologies. Also, 3D and 4D mapping techniques as a result of improved seismic technology provide better images of the subsoil and have further increased recovery rates’.

IOR in Norway has been facilitated by many government-funded programmes carried out since the early 80s. Kjøde: ‘The Norwegian government aims at even higher recovery rates and has set a target of adding 5 billion barrels of extra oil reserves in the period 2005-2015. This means an ultimate average recovery rate between 50 and 55%’. Every year, companies with outstanding innovative plans for the Norwegian Continental Shelf are recognised by the NPD. Last year’s “Improved Oil Recovery Prize” went to American contractors Halliburton and Baker Hughes, for contributions to advanced drilling and completion technology on the Troll field.

Real-time data

Enhanced oil recovery is partly realized by the development of digital fields. Digital fields combine smart technologies, such as smart wells - providing engineers and operators with real-time data about well conditions and the options for opening and closing well sections - with enhanced information and communication technology. These ‘fields of the future’ encompass a combination of new technologies and new workflows. Better work environments for personnel are an important aspect of digital fields, as technologies often change faster than people can adapt to them.

Oil companies expect to improve their recovery rates by 8-10 percentage points by applying digital fields. However, it is difficult to assess the influence on global oil production, as oil companies use different definitions for digital fields. The smart approach will also be applied to new fields or fields that are being redeveloped.

Unmanned smart field platform at Champion West, Brunei. Photo: Shell

> *‘We optimize production by improving the collaboration of people onshore and offshore’*

All major oil companies, such as Shell, Exxon, BP and the Norwegian Statoil Hydro, and big contractors, such as Halliburton and Schlumberger, are involved in digital fields, also called ‘intelligent fields’, ‘e-operations’, ‘e-fields’ or names referring to registered trademarks such as ‘Integrated Operations’ (StatoilHydro) and ‘Smart Fields’ (Shell). ‘On a global scale, about five consortia introduced research programmes developing digital fields, of which three in Europe,’ says managing director Jan Brouwer of TNO Built Environment and Geosciences. TNO collaborates with Shell and TU Delft in the Dutch consortium Isapp (Integrated System Approach Petroleum Production). The Norwegian programme ‘Integrated Operations’ (IO) was initialized by the Norwegian Technology Institute and StatoilHydro; in France the Institut Français du Pétrole (IFP) is developing a smart approach.

In this way, each party uses the smart concept to its own advantage. The Isapp consortium is developing technology for constantly updating the oil reservoir model, in order to be able to control production optimally. Brouwer: ‘Normally, a model of the substrata will only be set up once, during the exploratory phase. This computer model is static, and after years of production no longer correctly reflects the composition of the reservoir. Generally speaking, it will only be adjusted to the current situation if a decision to redevelop the oil field is made. We call the Isapp model “closed loop” in contrast to “open loop” because production data is constantly being looped back, based on which the model of the underground is adjusted.

In this way, production information prognoses should always agree with actual production information.'

Technology developed by Isapp will most likely be applied to potential "smart fields" in particular: known fields that were not taken into production in the past because of their position, size or oil quality; fields for which part of the infrastructure is lacking ("green fields") and - to a lesser degree - fields that have reached the end of their productive phase because of antiquated technology and which might be redeveloped ("brown fields"). Existing oil fields in Malaysia, Siberia and the North Sea are the focus of desk research currently being performed by more than 50 scientists.

In the Integrated Operations (IO) project, StatoilHydro emphasizes the use of communications technology. 'We optimize our production by improving the collaboration between our personnel onshore and offshore,' says Adolfo Henriquez, project director IO at StatoilHydro. 'Since a couple of years, all platforms have video meetings; we have one support centre that helps solve problems worldwide, no matter where they turn up. IO has made a serious contribution to the increase in oil production.' Statoil (before the merge with NorskHydro) saw oil production in its Norwegian fields rise by 13.2 million barrels per day in 2006, followed by 13.8 mb/d in 2007, for a total of $1.5 and $1.35 billion respectively of its total gas and oil increase. According to Henriquez, smart fields accelerate oil production more than they actually improve the recovery rate. 'Improvement in total recovery may occur in fields where, by reducing costs, production can be sustained longer.'

Complex areas |

Digital technology is especially useful in complex or remote oil fields, deepwater conditions or reservoirs containing gas/oil mixtures, and can be unmanned and operated remotely. In its global Smart Fields programme, Shell focuses on the special geological characteristics of reservoirs, such as thin oil rims and stacked reservoirs (a set of smaller reservoirs piled up on top of each other) to maximize resource value. Shell operates Smart Fields projects all over the world, such as in the Fahud salt sub-basin (Oman), Sakhalin (Russia) and Champion West, off the coast of Brunei in a shallow part of the South China Sea. Champion West is regarded as a complex reservoir because of a web-like geological structure of thin reservoirs.

For Norway, complex areas are a challenge as well, such as deepwater drilling projects and new wells in cold climates in areas like the Barents Sea. Recently, ConocoPhillips restarted exploration drilling in the shallow waters of the Ekofisk field - Norway's first oil field, located in the North Sea south-west of the Norwegian coast - to explore prospects in layers exceeding 5,500 metres below the seabed. At such depths, drilling and logging equipment are exposed to very high pressures and temperatures and the operations are time-consuming and costly. Other complex areas are located where potential oil/gas-containing sediments are situated below thick layers of lava. Kjøde: 'Seismic mapping below these layers is very challenging since large density contrasts prevent the seismic energy from penetrating the lava. Drilling in these areas is not so much a technical problem, but without acceptable imaging it could easily become a waste of money'.

Underground separation |

Another advantage of Isapp is the knowledge that this project generates about the possibility of underground separation of the waste gases that are produced when extracting oil. Brouwer: 'Separation of oil, water and gases now often occurs after the oil has been brought to the surface. Expensive oil separation installations are used. From an environmental perspective, it would be interesting to separate poisonous gases such as H2S under ground, as conditions are better.' TNO also expects Isapp to generate knowledge about the behaviour of gases and liquids at extreme depths. This knowledge may be useful in the application of underground storage of CO_2 (CCS) in depleted hydrocarbon fields and in enhanced oil recovery practices using CO_2 to improve production (CO_2 EOR).

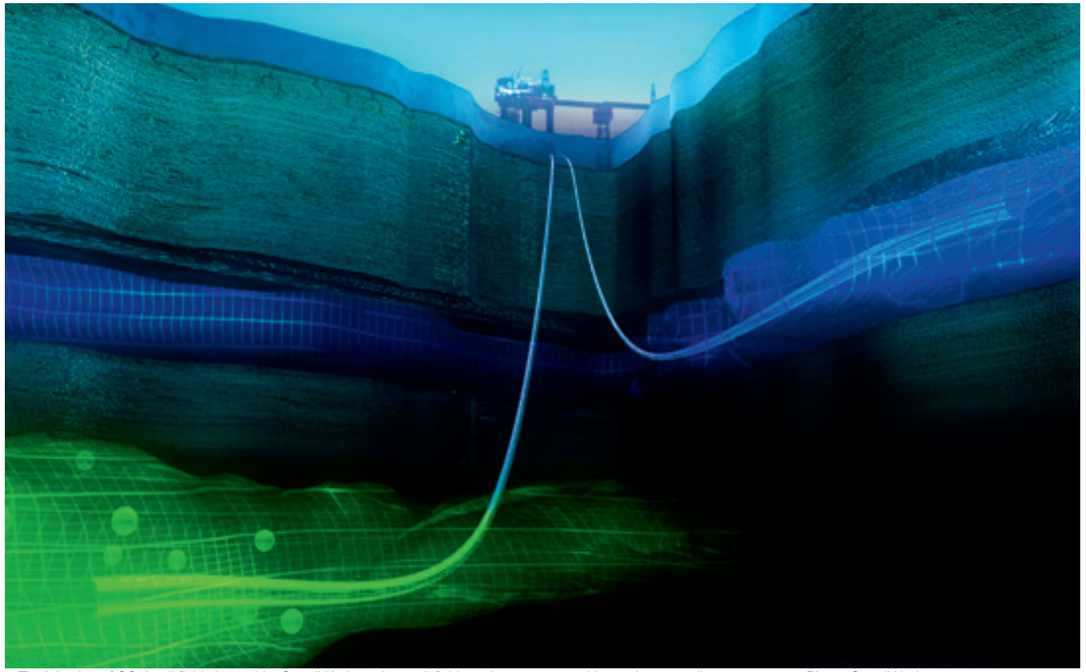
CO_2 EOR is a proven technique in onshore environments, mainly applied in Texas and Mexico. Applying the technology in offshore environments would be new. However, a study carried out recently by StatoilHydro on applying offshore carbon injection in combination with enhanced oil recovery – a project that would be carried out in collaboration with Shell – was unsuccessful. Henriquez: 'We performed in-depth reservoir studies in three fields: Gullfaks, Volve and Sigyn and had to conclude that the lack of readily available carbon and transport, as carbon dioxide combined with water under high pressure acts like an acid, are still too problematic and costly'. Statoil, operating the largest CO_2-storage project in the Sleipner field in the North Sea, where excess CO_2 from natural gas is removed underground and injected directly into nearby aquifers - expects that a combination of CO_2 injection with EOR under offshore conditions might become interesting if oil prices keep rising. ■

Enhanced oil recovery

In general, oil production is not an efficient process. On average, two thirds of the oil stays behind in the reservoir when a field is abandoned. There are two main reasons for this low recovery rate.

On a macro level, the inability to reach every corner of a reservoir is an issue. In addition, besides the naturally present water, injected water used to pressurize the oil will eventually rise to the top. When there is too much water, production must be halted. Macro returns for water-drive oil production, currently the most common technique, are approximately 60%. Even at a micro level, 60% returns are the maximum attainable because part of the oil will remain trapped in the pores of the reservoir rock formations (sandstone or limestone). Total efficiency therefore adds up to 60% of 60%, or approximately 35%.

Recovery rates depend largely on the technologies applied. Secondary water-drive technologies result in higher recovery rates than primary oil production techniques, when no liquids are injected into the subsoil. Enhanced Oil Recovery (EOR) or Improved Oil Recovery (IOR) are general terms for all sorts of technologies for increasing the recovery rate of traditional water-drive oil production, such as the use of polymers (which influence the migration pattern of oil), surfactants (a relatively expensive option), injection of gases such as carbon dioxide for its sweeping effect, thermal recovery by steam injection, and the use of microbes to decompose large oil molecules to increase the mobility of heavy oil (MEOR). EOR usually applies to improving oil recovery on a micro level, i.e. getting as much oil as possible out of the pores of the rock, whereas IOR also refers to the macro level ('sweep efficiency').



The injection of CO_2 in oil fields is used by Statoil Hydro to keep oil fields under pressure and hence improve oil recovery rates. Photo: Statoil Hydro

Growing oil demand

Global oil demand will continue to grow in the next decades, although its share in primary energy provision will fall from 35% to 32% by 2030. According to the International Energy Agency's World Energy Outlook 2007, oil production worldwide will amount to 116 million barrels (159 litres) per day in 2030, 32 mb/d (37%) more than in 2006. Future growth of the world's primary energy needs is estimated at around 1.8% each year.