Full speed ahead on Johan Sverdrup
The interview

Petroleum and energy minister Terje Søviknes wants to change what he calls the "bad guy" image the industry has acquired.

Student optimism

The downturn in applications for petroleum-related courses is flattening out as students take a brighter view of their prospects.

Minerals

The search for metallic minerals in the world’s ocean depths is under way.

Immobile oil

A new study assesses methods which can help to recover large amounts of residual oil on the NCS.

Sub-surface

Johan Sverdrup was discovered with the aid of masses of existing geological data which were re-interpreted, says Hans Christen Rannevik.

More to gain

The 50th anniversary of the start to oil and gas production from the NCS is approaching with less than half the resources recovered. Overall resources, including the estimate for those as yet undiscovered, have increased by more than 40 per cent since 1990.

Over the past two months, we have presented two reports which underline the big remaining oil and gas potential.

In our latest resource report for fields and discoveries, entitled with good reason Value for the future, we point to the huge quantities of oil and gas already proven and awaiting production.

At 31 December 2016, 77 discoveries were being assessed for development. And more can be produced from existing fields through improved recovery measures. A huge potential exists for using enhanced oil recovery (EOR) techniques.

Further details and the size of the volumes involved can be found in the resource report, which has been published at www.npd.no.

What is required to realise this value? First, the companies must take investment decisions on projects which have already been identified.

Second, the industry must collaborate to exploit existing infrastructure and adopt available technology. The NCS has been a laboratory for testing new technical solutions. It must now become a front runner in applying them.

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Out of the echo chamber

A mood of light euphoria grips Terje Søviknes after his first trip offshore, when he has literally looked down on Norway’s oil wealth. That made a big impression on the new minister of petroleum and energy.

Alliances. “People often find themselves in circumstances where they stay in their own echo chambers,” says Terje Søviknes. “If the petroleum industry is to have the future I hope it gets, it must build alliances with other social players.”
Technology represents the key to reaching climate goals, not prohibitions and restrictions.

The Progress Party politician says he is not often to be found in his office. He prefers to be hands-on, out in the field, where things are happening.

“I'm so incredibly impressed by this industry,” he cries. “We're a world leader in so many areas – subsea technology, rigs, clean production – there are so many things we can do.”

“I can’t imagine how it’s possible to run all this, the platforms and everything which happens far, far beneath the seabed. It’s the ultimate in engineering skill. It leaves me gasping!”

Søviknes enthuses about his helicopter ride out over the Norwegian Sea to visit Deep Sea Stavanger. The Odfjell rig is drilling production wells on Maria at the moment.

This field will be produced in an intricate interaction with neighbours Kristin, Heidrun and Åsgard, where the wellstream is to be piped to the first of these for processing.

Heidrun will deliver water for injection in the Maria reservoir, while the processed oil is transferred to Åsgard for storage and offshore loading. Gas goes to Kårstø near Stavanger.

“Just imagine, the rig runs two operations simultaneously – that’s so efficient, full speed ahead,” says Søviknes. “Once the field’s on stream, nobody can see it. Ships can sail right over the seabed facilities.”

He is a declared technological optimist. “Technology represents the key to reaching climate goals, not prohibitions and restrictions.”

Travelled The minister has begun to settle in after 100 days in the job. He has travelled all over Norway, talking to ordinary workers and company executives.

Visiting suppliers, technology enterprises, government agencies and oil companies, he has seen, asked, listened and learnt about their work, challenges, expectations and concerns.

“If you’re going to have a full understanding of the position, it’s important to meet people and be hands-on where things are happening,” he emphasises.

He has always been keen on the social perspective. “Politicians can’t do it all. As council leader in Os, I often worked for tripartite collaboration with industry and volunteers.

“That’s a good model. Cooperation with other players is extremely important, not least in the oil and gas industry. We mustn’t get too shut off.”

People often find themselves in circumstances where they stay in their own echo chambers, Søviknes observes. That can be secure and comfortable, but hardly forward-looking.

“If the petroleum industry is to have the future I hope it gets, it must build alliances with other social players,” he emphasises.

As the minister for Norway’s largest and most important industry, he has a responsibility for ensuring that the value created benefits the whole nation – including future generations.

In his view, the sector’s poor reputation is undeserved. “It reflects the combination of a couple of factors which emerged at roughly the same time.

“After the oil price slump in 2014, many participants in the public debate seemed to think oil revenues were no longer so important for Norway. There was much talk about restructuring and the green shift.”

Then came the Paris agreement and the big climate debate. “The result in Norway has been a very polarised discussion,” Søviknes says. “People are either for producing fossil energy, or they want to save the planet.”

He takes the reputational problem seriously. “We’re dependent on recruiting skilled hands and wise heads to continue developing the expertise base we’ve built up over 50 years.

“This base is the really big asset – it’s the one which allows Norway to lie among the frontrunners for technological progress and right in the lead within the oil and gas sector.”

Concerned Søviknes admits to being worried about the sharp drop in applications for petroleum-related courses. Few students mean it is only a matter of time before the teachers go too – which would be stupid, since the industry needs people in coming years.

He also worries about attitudes to oil among the young. “It’s super that youngsters are involved with and concerned about the climate, and they’re undoubtedly more idealistic than us older folk.

“But we must get across the fact that it’s possible to have both. We can reach our climate targets – and explore for and produce oil and gas.”

He appreciates that youngsters cannot be reached through traditional channels such as TV, radio and newspapers. “Both politicians and the industry must get better at being where young people are, and communicate more with them there.”

Søviknes has taken one step through his initiative on establishing a youth panel, and is recruiting volunteers.

“Students to help on the message – they’re undoubtedly more idealistic than us older folk. That’s extraordinary and unjust.”

He also finds the media debate is conducted between him as minister, a few politicians and the environmental organisations – not between the political parties and the voters. “That makes the exchanges a little rarefied,” he argues.

Asked to sum up the status of the NCS, Søviknes praises the job done by the oil companies and the suppliers sector in recent years.

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Perspectives Søviknes points to the recent report on Perspectives for the energy transition. Investment needs for a low-carbon energy system from the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA).

“They’ve produced scenarios on what can be done about the world’s energy position to achieve the climate goals set in the Paris agreement,” he explains.

“These agencies believe it’s important to invest in wind, solar and other renewable energy forms, but underline that demand for oil and gas will remain high.

Declining production from existing fields means that the companies must continue to explore and bring new discoveries on stream.

“The IEA/IRENA scenario for a low-emission society in 2050 assumes that as much as 40 per cent of the energy will come from fossil fuels.

“If that’s the case, why shouldn’t Norway also contribute? We have a tradition of being a front runner, and emissions from our production are among the lowest in the world.”

Although the trend is towards more renewables, oil and gas will continue to be produced. Norwegian gas can replace coal in the EU. The UK, for instance, has a clear policy in this area to reduce emissions.

In late April, Britain experienced its first day without coal-fired energy since the industrial revolution, and the government is resolved to eliminate this source by 2025.

Proud The minister is proud of Norway’s achievements in the oil and gas sector, and wants to eliminate the “bad guy” image which the industry has acquired.

“We must get much cleverer at relating value creation to things which mean something for ordinary people – schools, care of the elderly, transport, health, police and hospitals,” he says.

“Oil revenues finance the welfare state. Those working in the petroleum sector used to be regarded as heroes, now they’re rogues. That’s extraordinary and unjust.”

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Campagne
Following the exploration campaign in the Barents Sea this summer will be extremely interesting," the minister emphasizes. "Much of the attention in coming years will be on these waters."

"The future lies in the far north. Two fields are on stream there after 40 years of exploration - Snøhvit and Goliat. Alta/Gohta are now in the offing, with more searching to come. That's exciting."

He adds that the results of this year’s campaign will affect interest in the 2017 APA and the 24th round. A window of opportunity is open for boosting activity in the Barents Sea.

"The job the NPD has done in mapping the resources is very important. More of this may be needed, and a political discussion will then begin on whether the time has come for an impact assessment and a possible opening process."

Søviknes emphasises that the Conservative-Progress Party coalition has been fully aware of the importance of giving the industry access to new exploration acreage to maintain activity on the NCS.

Since it took office in 2013, 241 production licences have been awarded and consultations held on the blocks proposed for the 24th licensing round.

The government has also announced the 2017 awards in predefined areas (APA) with a substantial expansion of the acreage on offer, particularly in the Barents Sea.

"Big reserves still exist on the NCS," Søviknes notes. "The NPD has doubled its resource estimate for the Barents Sea, which is exciting in a longer perspective. It’s important to get across that we have assets to exploit for a long time."

The third success factor he highlights is the change in the player mix on the NCS. Statoil remains the heavy locomotive, but other smaller participants have contributed different perspectives and new methods.

Looking brighter
Things seemed very bleak when Marie Hilander Gjerde applied to study petroleum technology in 2015. “There wasn’t much positive feedback,” she admits. Today, she is buoyant about her job prospects.

"I’ve been in contact with a number of possible marks, and has taken on the job of chair. Stavanger is working hard to get the best possible mark, and her position at the head of Petroil chair. She believes the job market will look a lot better in two-three years."

"We must balance the debate and get the facts across."

What happened to the heroes? The petroleum and energy minister wants to talk the industry up – its “rogue” image is undeserved, he says.
create vacancies. We’re going to be needed.”

Vanished
More than 40,000 jobs have vanished in Norway’s oil sector since 2014, and hardly a week has passed without new headlines on downsizing and gloomy prospects.

That outlook has also been reflected in declining interest in university-level petroleum studies. After three years of falling enrolments, however, the decline appears to be flattening out.

Overall, applications this year are down by a further 7.5 per cent from 2014 for a three-year engineering BSc, and 16.2 per cent for maritime subjects. But figures for a five-year engineering MSc have risen by 6.4 per cent.

Three years ago, the UiS had four applicants for every place on its BSc courses in petroleum technology. Almost everyone who applies gets in today.

Øysten Lund Bø, dean of the UiS science and technology faculty, is pleased that the fall in petroleum engineering applications has slowed. They were down four per cent from 2016.

Upturn
But the UiS is also seeing more applicants for the BSc in petroleum geology and the five-year MSc in petroleum technology related to industrial economics.

The biggest increase has been for the courses on offshore technology, industrial technology and operations management, where numbers applying were up no less than 68.9 per cent.

Overall, petroleum- and offshore-oriented MSc programmes experienced a rise of 7.4 per cent.

The UiS is also seeing an increase in foreign applications.

Bø is hearing that changed acceptance criteria may be reflected in other types of questions being asked in lectures than before, which also exposes a slightly different starting point.

He nevertheless maintains that the quality of the petroleum courses and the students who graduate is high. The star candidates are still there.

However, he admits that new entrants collectively display a rather wider span of initial knowledge. That poses demands for the UiS in lifting the overall level during the period of study.

Secure
Lise Lyngnes Randeberg, president of the Norwegian Society of Graduate Technical and Scientific Professionals (Tekna), believes those who have opted for petroleum engineering for a long time to come, she emphasises. “We are a world leader in this area, which must be maintained and further developed.

“At the same time, we face a change of generations as many of those who joined the industry when it first blossomed begin to retire. We need renewal.”

And this is more than talk, she maintains. After several years of sharp growth in the number of cases related to downsizing and restructuring, the union’s lawyers are now dealing with more issues relating to contracts of employment. The change has been particularly clear since Christmas.

Effect
The same effect is being seen by Norway’s Labour and Welfare Service (NAV), reports Johannes Sørbo, senior adviser and labour market expert there.

For the first time in several years, the number of unemployed engineers and ICT specialists has declined over the first quarter of 2017.

Two factors appear to account for this – fewer redundancies in the oil and gas industry and more people securing a job, although the NAV cannot say exactly where.

“The signs are that they’re finding work outside the oil and gas sector,” Sørbo says. “We know this industry isn’t doing much recruitment at the moment.”

Sorry
Bo is confident of the job market facing students starting petroleum courses this autumn. But he feels sorry for those who fought for a place when they were hard to get, and who are now unemployed.

He wishes that the oil sector would think more counter-cyclically. “Students who’ve graduated to the dole queue in recent years meet very high quality standards.”

Classroom
In any event, Gjerde still has three years in the classroom before she has completed her BSc and MSc courses and will be ready to look for work.

Like her fellow students, she is working hard to gain good marks – and hoping that voluntary posts like chairing Petroil will count in her favour.

Her dream is a job with Statoil, but she knows she has to compete with many others who have a simi-
Building it on a big scale

Work on the first development phase for the Johan Sverdrup field involves no less than 14 000 people at 20 different places around the world. *Norwegian Continental Shelf* has visited a couple of these sites.

Rune Solheim (text and photos)

A huge blue crane capable of lifting more than 1 000 tonnes forms the gateway to Kvaerner’s yard at Stord south of Bergen. Immediately behind it towers the grey floater carrying the Njord platform topside, which has been towed in for upgrading.

Located centrally on the site, the workshop itself is currently fabricating and outfitting the bottom deck for the Johan Sverdrup quarters facility.

The whole shop is mounted on wheels and can moved aside as the structure grows. Other modules for the platform’s topside stand just outside it.

**Giants**

Much offshore history has been made at this yard, including work with a number of the giant structures on the NCS such as Statfjord A, Gullfaks A, B and C, Oseberg A and Troll A.

Also on the reference list are Snorre A and B, the Njord and Kristin facilities, and the Name and Åsgard A production and storage ships.

But today’s focus is on Johan Sverdrup, the field which has boosted optimism on the NCS. Kvaerner and US engineer KBR are building a topside with a nine-storey accommodation block.

This platform will also house the nerve centre for the whole field – the control room – and provide space for three helicopters on top.

One of these will be in a hangar on stand-by for search and rescue missions across the whole Utsira High area. And nine lifeboats will be available for the four field-centre platforms.

**Activity**

Johan Sverdrup is generating a high level of activity at Stord. The topside being built there will include the world’s largest offshore accommodation unit to date.

With 560 berths, gym, cinema and sick bay, this “marine hotel” incorporates a set of modules being outfitted only...
A few crane lengths away at sub-contractor Apply Leirvik.

Moreover, the support module for the drilling platform is taking shape at Aibel’s yard in Haugesund about 60 kilometres further south.

Kværner’s Verdal yard in mid-Norway has the job of building the three largest of the four steel platform jackets under an engineering, procurement and construction (EPC) contract.

The heaviest and most complicated jacket, intended to support the riser platform, is approaching completion and will be delivered this summer.

Design work for the drilling and process platform jackets was completed in the late autumn of 2016. Prefabrication and assembly of these are well under way at Verdal for delivery next year.

Proud

Construction manager Edmund Skålnes at Kværner Stord is pleased and proud that the yard proved sufficiently competitive to win fabrication contracts this big in an ever-tougher world market.

"We were facing a period of reduced activity when the Johan Sverdrup order was placed," says Skålnes. "That benefited not only us, but the whole Stord community."

The construction process has so far gone smoothly, reports Trond Ove Lerøy, who is the client’s on-site supervisor.

"It’s a great strength that well-known and tested components and building methods are being used. That both simplifies the work and makes it more secure."

No headaches

New technology often gives rise to headaches, cost overruns and delays for field developments. But that is not the case with Johan Sverdrup.

The challenge here is not the known technology, but the scale of the project and the many elements being built separately which need to come together at the right time.

"Fortunately, we’re well on schedule and haven’t had any serious incidents," says Skålnes. "Much of the necessary hardware was ordered even before we landed the contract. Along with good engineering work, that’s given us positive start."

Specifications and drawings are closely followed up, Lerøy explains. "Checking that everything’s been done correctly is a huge job."

"We have 70 000 sheets which have to be checked against the tag number for each component. It’s also very important that things arrive at the right time and place."

Skålnes adds that changes are not welcome. "These usually mean that we must take a step back and amend both plans and methods, which presents extra challenges for fabrication."

Stories

A few kilometres away, Apply Leirvik is building six of 11 components for the accommodation block, covering seven of its nine stories. The other two are coming from Kværner.

Construction began in April 2016, but preparations for tackling the Johan Sverdrup job were initiated as early as 2012. Hook-up and outfitting of Apply Leirvik’s modules started in May, with delivery due to Kværner in October 2018.

The company has long experience of building offshore quarters modules, extending from the...
Statfjord field in 1976 to the Gina Krog development last year. Operator Statoil produced a rough design outline and then left it up to Apply Leirvik to fill in the details. It is providing engineering services as well as building the modules.

The last two of the latter structures are being constructed by Apply Emtunga, the fabricator’s Swedish subsidiary in Gothenburg.

Control
“We’ve developed our own milestone system, a project management model, to maintain detailed control of both engineering and fabrication from start to finish,” says Øystein Kvalvik. Engineering leader for the accommodation modules at Apply Leirvik, he reports that 4 070 accommodation modules at Apply Emtunga, the fabricator’s Swedish subsidiary in Gothenburg.

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Design coordinator Odd Peter Øysjæter calls up detailed three-dimensional drawings of the quarters platform on a big screen. He explains that specific requirements are set for hygiene, ergonomics, lighting and noise where people will be present on the platform, in addition to all the technical specifications.

The 11 modules are designed to be hooked up very quickly. They add up to 14 500 square metres of accommodation – the rough equivalent of two football pitches.

Reversible
The quarters platform will have 450 cabins, and 110 of these are fitted with a reversible bed. That allows shift workers to share a cabin while retaining their own personal berth. Each cabin measures 7.6 square metres, with the bed placed crosswise to give more sense of space. All these units are delivered ready-built from Finland for immediate assembly.

Account has been taken of possible requirements for additional accommodation capacity, with mooring locations for three flotels provided on the field. The need to house as many as 560 people on the platform will only arise occasionally, during maintenance turnarounds and modification work. Normal field staffing will be about 220 people. Although the steel jacket might look a little flimsy in relation to the massive structure it has to support, all the weight calculations are in order.

The accommodation module is being constructed with the two lowest stories in steel and the rest in aluminium, which provides a weight saving of 1 000 tonnes.

If the cranes and helideck are ignored, this offshore hotel looks a bit like the superstructure of a cruise ship – with shiny aluminium surfaces pierced by rows of cabin windows.

It then remains to be seen whether the rest of the voyage will continue calmly towards the planned start of production in 2019.

Keeping it all together
Construction work for Johan Sverdrup, the new giant North Sea field, is ahead of schedule at the midpoint and could be NOK 26-27 billion cheaper than planned. Making sure things stay that way could be a challenge.

H allway is a milestone,” accepts Trond Stokka Meling, Statoil’s technical head for this phase-one project. “We’re entitled to acknowledge it, but not to celebrate. Everyone knows that the challenges could well arise in the second half. We can celebrate when everything’s finally put in place.”

Although the field is being developed with known technology, some things have not been done before. That includes the first use of Pioneering Spirit – the world’s largest heavy-lift vessel – for offshore installation.

This ship is due to install the topsides on Yme and Brent D. “We’ve made pretty formidable technological preparations to ensure that this will go well,” says Meling. “We also have a whole month’s weather window in summer – far more than the job needs.”

Platforms
The field installations will comprise four platforms, for drilling, risers, processing and quarters respectively.

Three large modules are due to be hooked up on the drilling platform topside during September, while others will be delivered by Aibel’s yard in Thailand.

With a drilling rig from the Nymo yard in Grimstad and the drilling support module from Aibel’s Haugesund yard, this platform is scheduled for towout to the field in the summer of 2018.

The riser and process platforms are under construction at the Samsung yard in South Korea and set to sail for Norway next year and in 2019 respectively.

Power
A high-voltage direct current connection (HVDC) facility supplied by South Korea will be installed on the riser platform as part of delivering power from shore to the facilities.

Preparations for the transformer station at Haugneset, just to the east of the Kårstø terminal north of Stavanger, are well under way.

This installation will convert...
alternating to direct current, with the HVDC turning it back to alternating on arrival – a process which minimises power losses in transmission from land.

The process generates a good deal of heat and radiation and therefore takes up a certain amount of space. Johan Sverdrup is to receive 100 megawatts from shore.

Control
The offshore control room will run all four field-centre platforms (set to rise to five in the second phase). These facilities will have a combined staffing of about 280 people.

In addition, the control room will manage the subsea systems, a possible unstaffed wellhead installation, and the power supply facility on land at Haugneset.

Part of an organisation of about 130 people linked to the field centre, the onshore operations centre will deploy real-time data and expert tools for support and decision-making.

Taking power from shore eliminates the need for big diesel or gas-turbine generating sets on board. But boilers needed by the process plant usually run on waste heat from the generators.

In the first stage, this heat will be provided by gas, with power from shore taking over in the second phase. The quarters platform will also carry a diesel-driven emergency generator.

Correcting anything out at sea is more expensive. A challenge arose after a bridge across an Italian motorway collapsed. Driving heavy vehicles over such structures was banned for a while in northern Italy, making it impossible to get equipment to the docks for shipping out.

“We were locked in,” says Meling. “Fortunately, we found roads which could be used and sent the freight by river barge to the coast and onto the cargo ship.”

Share
Asked how much of the Johan Sverdrup development is under construction in Norway, he says everything must fit together even though construction has been pursued at 20 sites around the world.

Meling underlines the importance of information being conveyed in a precise manner and interpreted in the correct way.

“All the equipment must work when it comes offshore. Interfaces, design and construction have to be done well. The preconditions must be the same at all the yards.”

He recently visited a supplier in Poland providing seven cranes. Follow-up is important to ensure that they work properly offshore.

About 70 per cent of the contracts have gone to companies with a Norwegian address. However, some of these are allocating part of the work to their foreign branches.

An example is drilling platform contractor Aibel. It has an office in Oslo and a yard in Haugesund, but is using its Thai facility for some work because of a lack of capacity in Norway.

Far lighter provides another case in point, with an office in Bergen while manufacturing its cranes in Poland. So the picture is nuanced, Meling points out.

“The suppliers have looked at how they can be competitive in an international market. They can often compete on engineering and hook-up, but need to weld steel in other countries.”

“When the company is Norwegian, we communicate with its management here. That’s clearly an advantage. In technical terms, however, we’ve no grounds for saying that Norway does things better than elsewhere as long as the specifications are met.”

Construcion
Around 14,000 people will be employed on the Johan Sverdrup project at peak, and the whole construction period involves 51,000 work years. But Meling is unsure how many of these are Norwegian.

A decision is due this summer on permanent monitoring of the Johan Sverdrup reservoir with the aid of four-dimensional seismic surveying.

This involves repeating three-dimensional surveys at regular intervals to check developments in the formations once production is under way.

While the cost of such surveillance has been included in the field’s plan for development and operation (PDO), it must be approved by the partners before 1 July.

Meling notes that opportunities to acquire sub-surface data on an annual basis will provide increased understanding of reservoir behaviour during production and water injection.

“That in turn allows us to improve the planning of new wells and methods for boosting resource recovery. Our ambition is to get out 70 per cent of the proven hydrocarbons.”

Operator Statoil and its partners have a 50-year production time frame, and need robust data to reduce uncertainty. That can improve the recovery factor and extend the field’s commercial life.

Fantastic
Meling describes the economics of Johan Sverdrup as fantastic. “When sanctioning phase one, the bill was put at NOK 123 billion. We’re now down to NOK 97 billion.”

“We’ve achieved fairly dramatic cost cuts, and a discussion has been under way in the Norwegian press on whether we’re putting too much pressure on the suppliers.”

“But we’re not interested in bankrupting them or undermining safety. We take great heed of health, safety and the environment. A project isn’t a success if we suffer a serious incident.”

“Our positive experience is that we’re getting what we ordered, to the right quality and by and large on schedule, so that we don’t have to spend heavily on repeating the work.”

Not at any cost. “We’ve achieved fairly dramatic cost cuts,” affirms Trond Stokka Meling, technical head of the Johan Sverdrup development. “A discussion has been under way in the Norwegian press on whether we’re putting too much pressure on the suppliers. But we’re not interested in bankrupting them or undermining safety.”

(Photos: Statoil)
Getting to the bottom of it

“Integrating all available data to detect possible degrees of freedom for formulating new hypotheses was the key to success,” says Hans Christen Rønnevik. This approach allowed him to spot the geological potential of the Utsira High in the North Sea.

Alice Ølberg Bore
Facts about Johan Sverdrup

- Oil field on the Utsira High in the Norwegian North Sea, 40 kilometres south of Grane and 65 kilometres north-east of Sleipner.
- Scheduled to come on stream on 1 December 2019.
- 70 per cent of the contracts awarded to companies with a Norwegian address.
- Profitable at an oil price as low as USD 20 per barrel.
- Will yield NOK 1 350 billion in revenues over a 50-year producing life.
- Tax revenues will total USD 670 billion.
- Peak daily production will be 440 000 barrels (70 000 scm) of oil and six million scm of gas for phase one, and 660 000 barrels (105 000 scm) plus 10 million scm for the full field.
- Water depth on the field is about 110 metres.
- Reservoir depth is about 1 900 metres.
- Covers about 200 square kilometres.
- Chosen solution for the first development stage is a field centre with four dedicated platforms for quarters, processing, drilling and risers, all linked by bridges.
- Drilling platform with 48 well slots is designed for simultaneous drilling, well intervention and production.
- Power from shore will be used throughout the field’s producing life. Phase two, due on stream in 2022, includes power for improving oil recovery. Producers will be placed high in the thickest parts of the reservoirs, with injection wells close to the oil/water contact. Producers and injectors are four-five kilometres apart.
- Stabilised oil travels from the riser platform to the Mongstad terminal near Bergen through a new pipeline tied into rock caverns. Gas goes from the same platform to the Kårstø terminal north of Stavanger via a new pipeline tied into the rich-gas arm of the Statpipe system west of Karmøy island.
- Water injection will be utilised as pressure support and gas lift in the production wells, along with other measures for improving oil recovery. Producers will be placed high in the thickest parts of the reservoirs, with injection wells close to the oil/water contact. Producers and injectors are four-five kilometres apart.
- Stable.

Sandstone on Wilhelmøya

“Where have these sand grains come from and how did they turn into rock,” is the question inquisitive geologists ask themselves when they look at sandstone outcrops.

NPD geologist Andreas Bjørnestad is seen here on Wilhelmøya – a remote part of the Svalbard archipelago where rocks analogous to the sandstone reservoirs on the NCS can be studied.

These sediments belong to the Svenskøya formation and were deposited in a shallow sea around 200 million years ago. The cliff has some horizontal layers at its base, overlain by strata formed in a near-shore deposition environment. Sandstone is fairly unconsolidated and can easily be scratched with a fingernail. Some fragments of fossil trees and bits of coal can be found at this location.
All the signs are that a decision on the Snorre Expansion project will be taken before the end of this year by operator Statoil and its partners. They are due to submit a plan for development and operation (PDO) which calls for the installation of six or seven large subsea templates providing up to 28 new well slots.

“That could allow Snorre to stay on stream until well after 2040 – 30 years beyond the original PDO forecast,” says Mørch, who is an assistant director for development and operations.

“Resource extraction will increase by at least about 190 million barrels (30 million standard cubic metres) of oil – equivalent to a Goliat field.”

**Fantastic**

He describes Snorre as a “fantastic journey”, with its estimated resources more than doubled since the start. “This makes it one of the biggest improved recovery projects on the NCS. It remains among the Norwegian fields with the most remaining oil.”

The NPD earlier believed that a third platform would be needed on Snorre, but this became “financially demanding” after oil prices slumped.

Many people have described the abandonment of the platform concept as a loss of prestige for the NPD, but Mørch rejects that view.

“Our most important consideration is – and has always been – to achieve a solution which takes care of the big resource potential on the field. In other words, more wells.

“Sanction for the new solution would be a victory for us. It provides the same level of resource utilisation and as many wells as a platform – with lower costs and improved profitability.”

Where does this resoluteness stem from? The spark was ignited back in 1992 when Mørch and colleague Bjørn Anders Lundschien produced reservoir models for Snorre.

Their aim was to determine whether water alternating gas (WAG) injection could drive out more oil. The pair wrote a paper on this issue which they presented at seminars.

That led in turn to a good dialogue with Saga Petroleum, the then Snorre operator, which had reached other conclusions in its WAG study. Mørch says the NPD model fitted the actual outcome.

**Difficult**

Qualified as a reservoir engineer, he has continued to work with Snorre through various roles at the NPD and explains that its reservoir is difficult.

Many solutions have been proposed to improve recovery from the field, which lies at a depth of 2 000-2 500 metres beneath the seabed.

The reservoir comprises Jurassic and Triassic riverine deposits from around 200 million years ago, and covers roughly 10 by 25 kilometres.

March and his colleagues have also studied this formation at close hand a number of times – and will be heading down again in September.

“More wells have been drilled on Snorre than anyone could have imagined when the field came on stream in 1992.”

**Battles**

Tough battles have been fought over Snorre in meeting rooms at the operator and the NPD. But Mørch nevertheless describes the dialogue as good.

“Positive collaboration with Statoil as the present operator and the other licensees mean we have jointly arrived at good solutions. “We’ve made it clear throughout what we consider prudent recovery.”

Generally speaking, the broad picture is a battle over investment cash and with senior management in big groups who believe they can

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**Patience is a virtue**

Working with oil and gas calls for long-term thinking – and endurance. Tomas Mørch’s first job when he joined the NPD in 1992 was to produce reservoir models for Snorre. He is still keeping an eye on this North Sea field.
get a better return elsewhere than the NCS.

“That’s their job, but they also have a clear responsibility to utilise Norwegian resources to the full,” emphasises Mørch. “Our job is to manage Norway’s oil and gas.”

“Pursuant to the Petroleum Act, all profitable resources must be recovered. The government won’t allow the companies simply to skim the cream.”

He believes that the NPD’s encouragement has been crucial in ensuring that the additional resources in Snorre and elsewhere are recovered.

“These developments involve major capital spending, to be sure. But such investment pays off – with a heavy heart.”

A somewhat overeager commitment also brought March into local politics in Randaberg local authority outside Stavanger, where he sits on various committees and is an alternate council member.

His inability to keep quiet drew him into the Christian Democrats. He told the politicians that Randaberg was the local authority in the region which paid most in road tolls for the smallest return. “That did it.”

Social issues interest him. He wants tax revenues to provide the largest possible value creation for society. “And that also applies to oil issues.”

His fixed term as an assistant director expires this autumn – he is actually on overtime. “I’m looking forward to new opportunities in the NPD, and will certainly work with the NPD, and will certainly work with the NPD.”

The Snorre reservoir is regarded as complex, and has given many an expert headaches since its discovery in 1979. Developing the field has been difficult and exciting, with three operators – Saga Petroleum, Norsk Hydro and now Statoil – and much conflict.

But all the discussions and disputes resulted in calculations and plans which have more than doubled estimated reserves since production began in 1992.

The original plan for development and operation (PDO) put recoverable oil at almost 750 million barrels (119 million standard cubic metres).

Steady drilling of new wells has helped to boost that figure to just over 1.7 billion barrels, and the new PDO due in late 2017 should boost this above 1.9 billion. That makes Snorre unique in improved recovery terms.

Saga’s initial PDO expected production to cease in 2012-14. As with so many Norwegian fields, however, the Snorre operator and licensees have learnt more, acquired better technology, become familiar with the subsurface and identified new opportunities.

Saga applied for only one operatorship during Norway’s eighth licensing round in 1983, covering block 34/7 in the North Sea west of the Sogne Fjord.

It secured that job, but on condition that it joined forces with an experienced oil company to act as guarantor for the selected development solution. The choice fell on Esso Norge.

A single installation was originally proposed, and Saga secured acceptance for the Snorre A tension-leg platform (TLP) tied to a subsea template.

Two options were initially in line for the next phase, either redeveloping the A unit to produce the northern part of the field or installing more templates on the seabed. But neither course was chosen. Instead, the Snorre B sub-template came on stream in 2001. In 2010-11, Statoil – now the operator – proposed installing just one template in the north.

Snorre was originally expected to be shut down three-four years ago. The government is now awaiting new plans to extend the producing life of this North Sea field until 2040 or beyond.

| Bjørn Rasen |

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Snorre was originally expected to be shut down three-four years ago. The government is now awaiting new plans to extend the producing life of this North Sea field until 2040 or beyond.
Exploring for minerals on the ocean floor has been under way in international waters for more than 15 years. Interest in these resources is also growing in Norway.

The presence of metallic seabed minerals in the world’s oceans has long been known. In some areas, these accumulations are of a size which may make them commercial – and thus to be regarded as ore deposits. These seabed resources were a key driving force behind negotiations on the UN International Law of the Sea treaty in 1973-82, which now regulates the rights to exploit them. A total of 27 active exploration contracts have been awarded for international sea floor areas, split between the three types of mineral deposit. These are manganese nodules, manganese crusts and sulphides. Each of them in turn contains a number of metallic elements and lies in water depths of 1 500-6 000 metres.

Under the UN Convention on the Law of the Sea (Unclos), a coastal state controls the resources on and under its whole continental margin – even where this is extends further than 200 nautical miles from land. The convention defines this area of national jurisdiction as the coastal state’s continental shelf – in other words, a legal rather than scientific definition of the term. It means that the NCS is not confined to the relatively shallow areas where oil and gas are found. It also includes waters several thousand metres deep and far from land, where exploring for other types of resources could be relevant.

Quantities

Found on soft seabeds in the deep ocean, manganese nodules contain large amounts of manganese and iron with smaller quantities of copper, nickel, cobalt, titanium and platinum. Manganese crusts also consist largely of manganese and iron, plus titanium, cobalt, nickel, cerium, zirconium and rare earth elements (REEs). They grow as laminated deposits on bare bedrock exposed at the seabed in water depths of 1 500-3 000 metres. Sulphides primarily comprise lead, zinc, copper, cobalt, gold and silver, and are linked to hot springs in volcanic spreading ridges beneath the oceans where "black smokers" form. These vents continue to spew out hot material for several thousand years before dying out and leaving behind mounds which con-
tained the bulk of the sulphide ore resources.

Sought

Such resources have been sought in the international parts of the ocean seabed for more than 15 years under contracts awarded by the International Seabed Authority (ISA).

The first of these areas went to seven pioneering investors in the 1990s, but their contracts only came into force in 2001 when exploration regulations for manganese modules were put in place.

Little happened until 2012, when the number of applications for the contracts suddenly rose substantially and remained stable for the next three-four years.

The jump in the number of applications coincided with the completion of the regulations governing the search for sulphides and manganese crusts.

It also occurred at a time when China was becoming the monopolistic supplier of a number of strategic minerals which are important for introducing ‘green’ technology.

Manganese crusts are expected to be a future source of such deposits in the rest of the Atlantic and in the Pacific.

Copper

Moreover, the world’s copper reserves on land – put at roughly 720 million tonnes by the US Geological Service (USGS) – appear to be running out.

They will last for only 40 years at today’s level of consumption, but demand is expected to rise substantially in the next few years in response to green technology needs.

That gives a much shorter timeframe for identifying further supplies. In that context, the USGS has put global copper resources in manganese nodules at about 700 million tonnes – roughly equal to current land-based reserves.

While the USGS has not published figures for copper resources in deep-ocean sulphides, others have put them at less than a 10th of the USGS forecast for manganese nodules – probably a very conservative estimate.

Exploration

Most of the contractors involved with the 27 active contracts are state-owned institutions, such as France’s Ifremer and BGR of Germany.

Private companies have also joined the hunt in recent years, including UK Seabed Minerals, Belgium’s G-Tec Sea Minerals and Keppel from Singapore.

All contractors must have official support from their own government, and 20 countries are currently backing exploration for these minerals. Five are developing countries – small island states in Asia and the Pacific.

The contracts run for 15 years, with the contractors originally expected to convert subsequently to a production phase. That has not happened.

Instead, all seven of the pioneer contracts have been given a five-year extension. At the same time, the ISA is working on regulations to govern expansion.

First

Production of minerals from international waters could begin during the next decade, with manganese nodules set to be the first target.

Long before then, however, Canada’s Nautilus company is likely to start output from the Solwara 1 sulphide ore field in 1 700 metres of water off Papua New Guinea’s continental shelf.

The mining equipment has already been designed and built, and a production ship will be ready in 2019. This activity could have a great influence on the industry’s development elsewhere.

Present

Where the NCS is concerned, seabed minerals are known to be present in deep parts of the Norwegian Sea. The University of Bergen (UiB) found black smokers there more than a decade ago.

Drawing in part on the NPD’s large multibeam bathymetric data set, acquired for boundary mapping, the university has identified a number of sulphide deposits.

Including both smokers and manganese crusts in parts of the deep Norwegian Sea and around the Yermak Plateau in the Arctic Ocean and Bear Island in the South Atlantic.

On the other hand, manganese nodules are not likely to exist in these waters, with the possible exception of the areas around Bouvet Island.

Commercial

The question now is whether these minerals are found somewhere on Norway’s continental shelves in such quantities and of such quality that mining them could be commercial. A lot more work and investigation is needed to provide a reliable answer.

To get the ball rolling, the NPD has carried out an initial series of chemical analyses of thick manganese crusts on steep slopes of the Jan Mayen Ridge and the Voring Spur.

These have revealed interesting differences compared with such deposits in the rest of the Atlantic and in the Pacific.

Manganese crusts in the Norwegian Sea fall into two groups in terms of their lanthanide content. One has twice the amount found in Pacific and other Atlantic sources, the other has less.

Both categories contain substantially more lithium (20-80 times as much) and scandium (10-30 times). These are interesting “green” metals.

The group with a high lanthanide content also has a greater proportion of yttrium, and is therefore richer in the whole series of REEs.

These findings are extremely interesting. The question now is why these chemical characteristics vary.

Metal content in manganese crusts from the Norwegian Sea compared with the Pacific.
Positive prospects for producing more

A very significant potential for enhanced oil recovery (EOR) on the NCS has been identified by a recent technical screening study of various available technologies.

Performed by experts from London’s Imperial College, this work addressed which EOR processes would be most suitable for the NCS and what incremental improvement could be achieved.

The study compared seven potential approaches with conditions in a number of Norwegian offshore reservoirs to determine how appropriate each of them would be for the respective formations.

- **High**
  - The recovery factor – or the proportion of oil originally in place extracted from fields on the NCS – averages 47 per cent, which is high compared with average global figures of slightly less than 40 per cent.
  - Various technologies can be deployed to enhance this recovery factor even further, and the following approaches have been used in or proposed for oil fields globally:
    - **Gas injection.** The principal gases used are hydrocarbons, CO₂ or nitrogen (or nitrogen-rich flue gas). Injected gas may be miscible – where the gas and oil dissolve in each other to create a more mobile fluid – or immiscible, with the oil and gas remaining separate phases.
    - Both miscible and immiscible injection are usually implemented in alternation with slugs of water. Such water alternating gas (WAG) processes are more effective at producing oil, since the water improves gas sweep through the reservoir.
    - Hydrocarbon gas injection has already been used successfully on the NCS (in Statfjord and Oseberg, for example). CO₂ injection has the added attraction that some of the gas will remain in the sub-surface permanently and thereby contribute to carbon capture and storage (CCS).
    - **Alkaline flooding.** Alkaline substances added to injected water react with the oil to produce surfactant compounds which reduce interfacial tension with oil and alter wettability. Both these outcomes can mobilise more oil from the rock's pores.
    - **Polymer flooding.** Water-soluble polymers added to injection water increase its viscosity and thereby improve water sweep through the reservoir.
    - **Surfactant flooding.** Surfactant added to injected water alters the wetting state of the rock and reduces oil-water interfacial tension, thereby mobilising more oil from the pores.
    - **Low salinity flooding.** Oil recovery during waterflooding can be improved by lowering the total salinity of injected water to less than 5 000 parts per million (ppm), and thereby making the rock more water-wet.
    - **Surfactant/polymer and low-salinity/polymer flooding.** In these processes, surfactant...
or low-salinity flooding (which improves microscopic displacement efficiency) is augmented by adding polymer to improve water sweep.

• Gels and thermally activated polymers (TAP). These improve sweep by shutting off specific water flow paths close to producer or injection wells (gels), or deeper in the reservoir (TAP).

Each of these EOR processes has specific envelopes of conditions within which they will perform optimally, or outside which they will not work at all.

In the current study, 53 reservoirs and segments were evaluated in 27 fields, using such screening criteria as lithology, depth, pressure, temperature, oil API gravity, viscosity, oil acidity, oil wetting behaviour, and reservoir porosity and permeability.

Reservoir thickness, fracturing, heterogeneity, clay content, clay type, formation water salinity, injection water salinity, remaining oil and current recovery process were also taken into account. These screening criteria cover a wider range than those used in other published studies, which thereby enhances the sensitivity of the method. Reservoir data contributed by field operators were screened using the criteria above with the aid of a specially constructed software toolkit.

**Effectiveness**

Viable EOR processes were assigned recovery increments as a function of the generic effectiveness of the recovery process derived from global EOR project data, a suitability score and the field oil in place.

The suitability score quantifies the applicability of a given EOR process in a specified field. These scores were generated by the screening toolkit using the technical criteria, weighted for importance. They vary between 0 and 1, where a score of zero means that the process is not viable and one means the process is optimal for that field. EOR processes with a zero score are assigned a zero recovery increment.

The EOR potential was estimated as the recovery increment for the top EOR process in each field – in other words, the one with the largest recovery increment.

When applied across all 27 fields studied, that gives an EOR potential of 590 million standard cubic metres (scm). This is the mid value in a range of possible outcomes based on an estimated technical potential of 320-860 million scm. The NCS clearly contains a very significant EOR potential (see figure on page 33).

**Applicable**

Four EOR processes are widely applicable and have mid-case technical potential recovery increments of over 40 million scm.

• Low salinity/polymer offers the largest large potential increment, mainly from fields in the Utsira High and Tampen areas of the North Sea.

• Surfactant/polymer suits similar fields, but only performs better than low salinity/polymer in a few fields from the Tampen area and the Halten Bank in the Norwegian Sea.

• CO₂ injection is promising in fields where this gas is expected to be miscible at reservoir conditions. These are mainly the chalk fields in the greater Ekofisk area and fields in the Tampen area.

• Hydrocarbon gas injection/WAG is potentially viable in many fields, and is already the most widely deployed EOR process in the North Sea. Clear geographic trends for the applicability of EOR processes can be seen, and these could have important implications for economies of scale and injectant supply.

The figure on page 34 shows two areas where the same EOR method is the top opportunity for all the fields within them.

Other EOR processes (low salinity, gels, alkaline flooding) are viable for niche conditions in certain fields.

While low-salinity flooding, for example, is not as effective without added polymer, it is viable on fields which are either too hot for polymer deployment or have very low-viscosity oil where polymer would add no benefit.

Gels and thermally activated polymers are viable in very mature fields to improve sweep and control water production.

**Factors**

All the fields in the study have some EOR potential. The amount of incremental recovery for a specific field depends on two factors – first, the existence of an EOR process which is fully optimal for that field with respect to its screening criteria and, second, the remaining field oil in place.

The amount of remaining oil, in turn, depends on the initial oil in place and the amount produced from the field so far.

**Potential**

This screening analysis gives an indication of the technical potential for EOR. The next steps are to apply rigorous operational, commercial and environmental screening criteria to determine more accurately the size and location of the practical potential.

The study recommends that the current work be followed up by a gap analysis to determine the main barriers to implementing EOR processes and an in-depth analysis of the most promising fields using a reservoir technical limits type of approach.

Further research may also be needed to develop some of these processes for the more testing conditions found in certain of the offshore fields, and to investigate the potential synergies between EOR processes and CCS.
Value for the future

New resource report for fields and discoveries

Available at http://resourcereport2017.npd.no