

**We must  
continue to  
explore**

**NORWEGIAN**  
CONTINENTAL **SHELF**

A JOURNAL FROM THE NORWEGIAN PETROLEUM DIRECTORATE NO 2 - 2018



Photo: Monica Larsen

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**Banking samples.** The NPD's rock store has been redesignated the Geobank because, as well as cores, it contains microfossils and frozen oil samples from virtually every discovery and field on the NCS.



Photo: Monica Larsen

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**The interview.** "We must continue to explore. And we must have acreage to explore in," says Kristin Færøvik, chair of the board of the Norwegian Oil and Gas Association.



Photo: Monica Larsen

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**Carbon chaser.** NPD geologist Eva Halland is investigating opportunities for storing huge quantities of CO<sub>2</sub> deep beneath the seabed on the NCS.



NORWEGIAN PETROLEUM DIRECTORATE

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**NO 2 - 2018**

VOLUME 15

**RESPONSIBLE PUBLISHER**  
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**PRODUCTION**  
Printer: Kai Hansen  
Paper: Arctic Volume 200/130 g  
Print run Norwegian: 10 000  
Print run English: 1 500

**LAYOUT**  
Arne Bjørøen

**SUBSCRIPTIONS**  
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Sulphide deposits have been found on the NCS. These minerals are important for your mobile phone.



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Photo: NRK

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Norwegian TV series *Lykkeland (State of Happiness)* has reminded the country's residents of the courageous decisions taken in Stavanger ahead of the oil adventure.



Photo: Rune Solheim

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### Go for gas.

Norway's position as a gas exporter could be weakened unless the companies adopt a more aggressive approach to exploring for this resource.

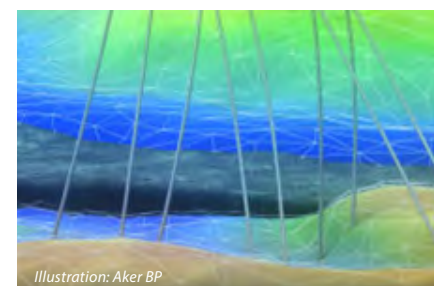


Illustration: Aker BP

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### Award winners.

The three companies which shared the NPD's 2018 IOR prize for their work on the Alvheim field give the background for their ideas and mode of collaboration.

## Gas, of course

The Aasta Hansteen gas field began production on 16 December as the first development in the northern Norwegian Sea. At the same time, the new Polarled pipeline began carrying natural gas to Nyhamna near Ålesund for export to European customers. All this opens new opportunities in the area around Aasta Hansteen and Polarled.

In recent years, Norway has exported some 120 billion standard cubic metres of gas worth about NOK 200 billion. Most energy forecasts show a growth in demand for gas, while declining domestic production in the EU could create an increased need for European gas imports. Were gas to replace coal in electricity generation, CO<sub>2</sub> emissions could be halved.

In my view, this is not well communicated in Norway.

The NCS has produced more gas than oil since 2010, and that position is expected to persist.

Substantial resources, closeness to the market and an integrated and flexible transport system with low unit costs have made Norwegian gas competitive in the European market.

If the country is to maintain its gas exports from the mid-2020s, however, offshore exploration activities must be stepped up and more resources found in coming years.

Almost two-thirds of Norway's undiscovered gas resources are expected to lie in the Barents Sea, which underlines the importance of this area for long-term gas exports from the NCS.

The key lies in the Barents Sea, and it is important that the companies explore for gas so that resources are found which can lay the basis for new infrastructure.

We are working with Gassco to identify requirements which will allow fields, discoveries and resources yet to be found to form the basis for more export capacity from these northern waters.

After two years with few exploration wells, their number is fortunately back at more than 50 per year. We hope this is a sign that such drilling has returned a new and better track – for gas as well.



*Bente Nyland*  
Bente Nyland  
director general



# Talking the business up

*Being part of the Norwegian oil and gas industry is a source of great pride to Kristin Færøvik. "I'm proud of what this industry achieves every single day, and of the continuous contribution we make to Norwegian prosperity," affirms the chair of the Norwegian Oil and Gas Association. "Quite a few people – who're familiar with economics and know better – fail to mention this when they deliver a speech. That probably reflects Norway's negatively charged public debate on oil and climate."*

**Popular backing.** Norwegian Oil and Gas and Færøvik have noted that three out of every four people in Norway consider it is important to retain the petroleum industry.

| Bjørn Rasen and Monica Larsen (photos)

Such sins of omission by important opinion-formers have left Færøvik almost speechless more than once, particularly when she considers who was on the rostrum.

And striking somebody from Bergen dumb is a serious business. At the end of our interview, the conversation returns to the topic we started with – the industry’s reputation.

Our discussion takes place where Færøvik spends most of her time as CEO of Lundin Norway – its impressive premises at Lysaker just outside Oslo. Her office has an excellent view, but she is primarily concerned with the outlook for the industry.



**Big share.** Færøvik points out that exploration activity has increased following the entry of new players – who account for a large proportion of discoveries in recent years.

Norway’s petroleum champions, who were plentiful during the early decades, have departed. Oil is now associated with climate change, and the heroes have become villains – to summarise the picture often painted in the public debate, at least.

Færøvik believes the image is more nuanced. “I’m not so sure the industry actually has a poor reputation. The voices which don’t wish us well get a lot of coverage. A polarised debate is perhaps of greater interest to the media than a rather more complex discussion.

“At the same time, we in Norwegian Oil and Gas see that the industry could be more open than it has been in the past, and talk more *with* rather than to those who challenge us.

“The world indisputably needs energy. There’s room, and a demand, for petroleum. It’s equally indisputable that we must produce it in a way the world accepts. That we accept this duality doesn’t emerge clearly enough in the debate.”

Norwegian Oil and Gas constantly measures popular support for the industry, and finds it good and broad-based – three out of four Norwegians say retaining the sector is important.

But Færøvik accepts that this backing varies with age and geographical location, and that it is particularly important for the industry to establish a good dialogue with young people.

### Advanced

“The question we ask ourselves in the industry is *how* we should operate with oil and gas in Norway,” she says. “We’re a very advanced industry.

“That’s because we’ve had farsight-

ed governments thoroughly regulating what we do, and because as a sector we have set goals which go beyond the legal minimum through our road map for 2030 and 2050.”

She finds it hard to penetrate the sound barrier with the positive stories. Things going wrong get the biggest coverage. Creating an understanding of the technologically advanced nature of NCS operations is difficult.

“And we mustn’t forget our unique supplies industry, which competes globally. I think it’s sad that this hasn’t attracted more attention.”

She also expresses surprise at the rhetoric from a number of people in industry and from many opinion-formers in Norwegian society.

“They’re perfectly well aware of how important this industry is for the economy, but they don’t talk about it. They should, even if they’re naturally concerned to see the country fulfil its obligations under the Paris agreement.”

And Norway can stay within those terms while also maintaining an active

oil and gas sector, Færøvik maintains. “We’re very ‘competitive’ globally on emissions and the way we operate.”

She points to comments by other experts that it makes no sense for the NCS to shut down first, either from a national, economic standpoint or in a global energy and climate perspective.

### Parameters

Asked whether existing operating parameters promote continued activity, the industry’s foremost representative takes a brief moment to consider the question before responding.

“We’re dependent on predictability and stability. I don’t hear any signals that the operating parameters on the NCS ought to be revised.”

In her view, stable parameters have been and are a competitive advantage for the Norwegian industry.

Nor are any amendments needed to boost activity on mature fields, she says. “Not right now. Stability is the most important consideration.”

She also says this out of consideration for the new players who have entered and will continue to enter the NCS. They have to know what they are coming to, without sudden negative surprises.

“Look back and see what happened when the government made provision for new players in 2004. The figures show a radical change in who was drilling exploration wells.

“Getting in new companies has had an effect on exploration activity. The other aspect is what has been found in the same period, with newcomers responsible for half the discoveries made.”

Færøvik believes this relates to the maturity of parts of the NCS. What is not material for a big company may be profitable for Lundin, for example – and this has been the trend in recent years.

### Smaller

Not only have more small companies moved onto the NCS, but most discoveries are also smaller. Production is outstripping new resources. Færøvik has only one prescription.

“We must continue to explore. And we must have acreage to explore in. The government must continue with the awards in predefined areas (APA).”

She also wants to see that blocks awarded are not left unused for long periods. If they are not being worked with, these licences must be relinquished. Acreage can thereby be recycled.

“We’re dependent on predictability and stability. I don’t hear any signals that the operating parameters on the NCS ought to be revised.”

Many of the discoveries in the Norwegian North Sea over the past decade were made in acreage which had been awarded and then relinquished, she points out.

“Production licence no 1 is an excellent example,” Færøvik adds with a broad smile. This was the recycled area where Lundin made its major Johan Sverdrup discovery.

Her attention then turns to the Barents Sea, where a huge area is available to explore and where the industry has only just got going.

She observes that relatively few wells have been drilled in the far north compared with the numbers in the North Sea. And she is convinced that more can be found there.

“We base that view not only on our own assessments but also on the NPD report on undiscovered resources [which puts the bulk of them in the Barents Sea]. The NCS is still attractive.”

Færøvik admits that the road to the big resources is becoming ever

more demanding. After all, the easiest discoveries have been made.

“So we’re very dependent on technological progress,” she says. And that is being made – in such areas as seismic surveying, for example.

New solutions are providing much better images of the sub-surface than before, supplemented by innovative data acquisition methods.

### Lessons

A different and depressing picture is provided by cost and oil price curves for the past five-six years. Can Færøvik, as the industry’s top representative, promise that her member companies have learnt the lessons from the painful downturn they have been through?

“I hope so,” she replies. “The responsibility lies with each company. Our concern in Norwegian Oil and Gas is to follow up and operationalise the KonKraft report published in January 2018.

“We have no intention of dropping that work and the report’s recommendation, even if the actual work is being done at the companies.”

She has received no signals about changes in behaviour so far. But some might perhaps need to be considered now that times have improved.

“Parts of the supplies industry may have entered into contracts which aren’t sustainable in the long term,” she concedes. “Adjustments could be made there.”

That is simply because suppliers must have enough of a margin to make a living. Færøvik nevertheless emphasises that they themselves must deal with overinvestment in capacity – supply must be tailored to tomorrow’s realities and needs.

This is also in the interests of the oil companies, she believes. “The way we collaborate will persist. I don’t see any signs that anyone wants to let go of that.”

She cites equipment and spare



**Waste not.** “One of the most important things we can do is to put a stop to waste – at every level,” says Færøvik. “That applies to the petroleum sector as much as to every one of us. Prosperity calls for energy, travel calls for energy – and we could go on and on in the same vein.”

parts as an example of where efficiency improvements and coordination are required. Each company holds its own spare part stocks today, often in the same warehouse as a competitor.

In her view, overviews must become available on a digital platform. "We must stop procurement being duplicated, triplicated or more, the way it is today. I envisage a much more efficient supply chain in the future."

### Capacity

That brings her to the new reality which a huge increase in data processing capacity has created, and she again cites seismic surveying as an example.

This sector is precisely about increased data storage and processing. At the same time, that has become cheaper and much faster.

To strengthen exploration for oil and gas even further, Færøvik wants all information from every available well to be accessible.

"We have vast quantities of data from all the wells drilled on the NCS," she notes. "The NPD, not least, holds huge amounts which aren't so easily accessible. We want them digitalised."

That could lead in turn to better and more efficient drilling in the hunt for new discoveries. Operators can see relationships they failed to detect in wells during the 1980s, for example.

"Our ability to relate such information to other available data opens completely new possibilities," observes Færøvik. "That's what happened, after all, when we found Johan Sverdrup – which started with the Luno discovery."

She adds that the whole model for operations on the NCS is changing as a result of the opportunities provided by increased data capacity.

"We have access to all the information in the office on land. We're no longer dependent on going offshore to get hold of it."

All the operators are moving towards condition-based maintenance, for example, replacing the calendar-based approach which has been

the most normal method in the past.

Maintenance is thereby based on the actual and physical status of the equipment concerned.

Færøvik says the offshore workforce will undoubtedly become smaller, and those left on the platforms face a different working day. Paper will disappear, with everything they need on a tablet.

"We've got to change the way we work in order to reap the full benefit offered by the opportunities," she emphasises.

All the changes demand that companies qualify their operators to master a new working life, Færøvik says. They need to invest in the expertise of their employees. And the industry must show the young that it can offer interesting jobs.

"It's a question of credibility in relation to a labour market. And we must present all our interesting activities – the most exciting things you can imagine in technological terms."

Being allowed to work with top technology is not enough to attract the most talented youngsters to the industry, she admits, and fully understands that "climate" plays a key role.

"All we can do is to show how we operate, that we do our job in a responsible way, and that room still exists for oil and gas in the energy mix."

"Those following in our wake can very much be involved in influencing the way we take the petroleum sector forward. That'll be with less energy consumption and even smaller emissions."

### Significant

This will be necessary if the industry is to go on being hugely significant for Norway's continued prosperity, Færøvik emphasises. And everything must be put in perspective.

Norway supplies the world with energy, which it needs. "We can manage here with hydropower. But that's not the case elsewhere. Almost a billion people still lack electricity."

She also points to Norwegian gas as an important contributor to reducing energy-related emissions in



**Far north.** Færøvik notes that relatively few wells have been drilled in the Barents Sea, compared with the numbers in the North Sea. "Huge areas are available to explore. After all, we've only just got going in the Barents Sea."

Europe. And she notes that petroleum has become essential to daily life.

"About 40 per cent of oil and gas output is consumed by the petrochemicals industry, making products we surround ourselves with. Try to imagine a home without them."

Færøvik, too, is concerned about the footprint which will be left behind. Responsibility rests on the oil and gas industry, she agrees. But also on the consumers.

"One of the most important things we can do is to put a stop to waste – at every level. That applies to the petroleum sector as much as to every one of us. Prosperity calls for energy, travel calls for energy – and we could go on and on in the same vein."

As the CEO of Lundin Norway, she has seen that cost-consciousness can be translated directly into emissions and discharges.

"Avoiding waste is the most important thing I can do for the environment in my job. And that gets reflected on the bottom line."

# ROCKSHOT

## The indispensable sulphides

Alexey Deryabin

Sulphide minerals play a major part in the everyday life of a modern human. They are the source of industrial metals which get mobile phones, computers and electric cars to function.

These resources have historically been extracted from deposits on land. In recent times, however, mid-ocean

ridges worldwide have been assessed for extraction.

The NPD conducted a successful expedition in the summer of 2018 on the Mohns Ridge, which discovered deposits from black smokers and adjacent rubble heaps of sulphides on the seabed.

This newly discovered area of sulphide minerals contains many such heaps and collapsed black smokers, including an inactive one 26 metres high as well as some active systems.



**Seabed minerals.** Black smoker from the NPD's expedition photographed in 3 000 metres of water on the Mohns Ridge in the Norwegian Sea. (Photo: Jan Stenløkk)



“I envisage a much more efficient supply chain in the future.”

# Climate for investment

Whether Norway's petroleum industry is particularly vulnerable to climate risk represents a pertinent question today. If so, should the government work to reduce this exposure? Moreover, does a danger of overinvestment exist on the NCS – and does the Barents Sea pose a particular climate risk?

| Petter Osmundsen, professor of petroleum economics, University of Stavanger

**D**emand for oil is continuing to rise. According to the base scenario recently presented by the International Energy Agency (IEA), this reflects population growth, increasing consumption in

developing countries and expanding use by petrochemicals, road haulage, shipping and aviation. Oil prices are expected to be USD 88 per barrel in 2025 and USD 112 in 2040.

The proportion of gas in NCS production has been rising over a long

time, and demand for this commodity is expected to rise strongly.

Even in a scenario with dramatic climate measures, which few people consider likely, a substantial need will exist for increased investment in the petroleum sector.

Moreover, the competitiveness of the NCS is good. The downside associated with the climate thereby appears limited. But were such a downside to materialise, how would it affect Norway?

## Similar

Climate risk, defined as the economic risk related to climate change, is basically similar to any other category and is handled by companies in the usual way.

Direct costs of releasing greenhouse gases are internalised through emission allowances and taxes.

Norway's regulatory regime for the petroleum sector delegates assessment of price risk to the oil companies.

The latter work with this on a daily basis, have hired experts and are also investing in new energy. It is hard to see how the government could assess this better while regulating the companies precisely and continuously with no efficiency losses.

Climate risk does not operate in only one direction. It must be assessed in relation to company expectations, where climate policy, for instance, could be less interventionist than expected.

In addition, prices could be lower and abatement costs higher than the companies have forecast – but the opposite might also apply.

The IEA scenario reveals clear concerns over supply. Capital rationing by the companies means few new discoveries or developments and record-low reserve replacement.

Fears are expressed of an oil supply crisis over the next decade. So a strong probability exists that oil prices will be considerably higher than the base estimate.

## Competing

A 2015 investigation by Norway's auditor-general revealed that the companies have a higher required return than the government and that the NCS is increasingly competing with projects elsewhere. Only the most profitable developments are realised.

Given limited company access to capital, the study concluded that even projects which show a positive present value with the companies' own required return are not necessarily implemented.

The auditor-general expressed concern over the lack of commitment to socioeconomically profitable meas-

ures to improve recovery from mature fields.

Underinvestment on the NCS has also been identified by Wood Mackenzie (2018a). The reasons for this can be split into several independent factors, including the higher required return mentioned above.

A recent Wood Mackenzie study (2018b) indicates that a representative real required return for oil companies is 11-13 per cent, compared with seven per cent for the government.

In addition comes the capital rationing mentioned above – the oil companies require present value to be at a certain level. See Emhjellen and Osmundsen (2017) and Emhjellen et al (2017).

This is best illustrated by the fact that the oil companies have an oil price expectation of USD 70 per barrel and above, but require projects to be profitable (given their high required return) at a breakeven price of around USD 35 per barrel.

A further buffer is Norway's petroleum tax regime, which gives companies a much lower return post-tax than pre-tax. See Osmundsen et al (2015), Wood Mackenzie (2018a) and Lund (2018).

This means that the internal rate

“The auditor-general expressed concern over the lack of commitment to socioeconomically profitable measures to improve recovery from mature fields. Underinvestment on the NCS has also been identified by Wood Mackenzie.”

of return must be several percentage points higher before tax in order to achieve a given post-tax outcome.

The pre-tax return which an NCS project must deliver in order to be sanctioned is therefore much higher than the government's requirement. The gap between these two positions represents an efficiency loss to the economy.

So the problem on the NCS is not stranded assets but underinvestment. Projects delivering a profit far higher than can be obtained in other industries are failing to be approved.

### Differential

What counts is not the oil price alone, but the differential between it and costs. Simple analyses of downside risk on the NCS typically reduce the oil price while keeping costs constant.

When the price falls, however, so do most cost components:

- rig rates drop, see Skjerpen et al (2018)
- drilling speed increases, see Osmundsen et al (2010, 2012)
- oil service charges go down
- rates for personnel hire fall
- fabrication costs drop
- cost overruns are reduced, see Dahl et al (2017).

This list could be extended. The petroleum sector makes great use of outsourcing, with rates set in a market which responds to the level of activity. Cost components are not sticky, as economists usually assume.

When activity declines, so do factor prices. The average quality of inputs increases and project control improves, so that productivity rises.

Only the most suitable rigs and the most competent specialists and project managers get hired. This com-

ination of higher productivity and lower input prices yields big cost cuts.

The papers referenced above show local elasticities which cannot be straightforwardly applied during major price downturns of the kind seen in 2014.

These reductions have the supplementary effect that they initiate system improvements, such as cost cuts for development concepts.

Equinor reports that it expected to require an oil price of USD 70 per barrel in 2013 to ensure that the projects being pursued were profitable.

For a corresponding portfolio today, however, it only needs crude to be trading at USD 21 per barrel to achieve project profitability.<sup>1</sup>

A number of analyses of downside risk in Norway's oil sector therefore lack scientific validity. The industry's swift and extensive response to lower prices indicates that profitability is far less dependent on crude prices than many think.

This finds its clearest expression in the fact that petroleum shares correlate more to the market index than to the oil price.

### Positive

Thanks to shallow water and reservoir depths as well as the Gulf Stream, the Barents Sea differs economically in a positive way from other Arctic waters.

The Gulf Stream means this area is largely ice-free, making it significantly easier to pursue petroleum operations there.

Similarly, relatively shallow water and reservoir depths make drilling significantly simpler and cheaper. Exploration wells now cost only NOK 200 million.<sup>2</sup>

According to Norwegian and Russian sources, the combination of cheap drilling and relatively large dis-

coveries (twice the size of the North Sea) means low finding costs.

Development costs are said to be competitive, although a lack of infrastructure could mean they are initially higher than in the North Sea for smaller discoveries.

The Barents Sea is frequently described as a high-risk Arctic area. Oil projects there are often seen as profitable, but the financial viability of gas production in this area is questioned.

While oil developments have a short payback time – often only a few years – repayment usually takes longer for gas projects.

On the other hand, gas yields lower emissions and is therefore expected to be less vulnerable to climate measures. A paper from Lindholt and Glomsrød (2018) at Statistics Norway and climate research specialist Cicero addresses this.

This identifies gas as a low-carbon alternative to coal in power generation, and finds that Arctic output of gas will be higher than today even in a two-degree scenario.

Modelling shows a steady increase in gas from the Arctic NCS replacing coal, with a tripling in relation to the 2012 reference scenario by 2050. Norway does better than other regions because of lower costs and quicker start-up.

The Johan Castberg development in the Barents Sea is set to be paid off in two years. An impact assessment in June 2017 estimated this field's socioeconomic value at NOK 85 billion in 2016 value. Of this, NOK 62 billion falls to the government through taxes.

With a breakeven price of USD 31 per barrel,<sup>3</sup> Johan Castberg alone would pay for more than 400 exploration wells at today's rates. So far, 130 of these have been drilled in the Barents Sea.

This means that, for all practical

purposes, the profitability of exploring the Arctic NCS has already been assured by a single field – assuming its development proceeds as planned.

### Growing

The new IEA scenario finds the downside for oil to be small and paints a uniformly positive picture for gas, which forms a growing share of Norwegian output.

But how would Norway be affected if the world's nations, against expectations, were to agree on adopting drastic climate measures?

Gas accounts for the larger share of NCS resources, and demand for this commodity is set to rise even with stringent action to curb emissions.

And crude prices would still provide scope for extensive oil activities on the NCS, even with a tough global regime for the climate. Repayment times of just a few years reduce risk.

It could be argued that the recent downturn suffered by Norway's oil sector has been a full-scale experiment in how resilient the industry is to falling prices. This slump was much faster and bigger than is likely with tough climate action.

The Norwegian petroleum sector has shown great flexibility. Costs have been drastically cut, and high profitability restored. And the government pension fund – global permitted the adoption of counter-cyclical measures which lower the macro-economic impact.

In practice, the industry has repudiated crisis scenarios for the NCS where researchers – who should know better – have reduced oil prices while keeping costs constant.

Reduced activity means a sharp decline in rates and a considerable improvement in productivity, which jointly moderate the economic effect of falling prices.

The oil companies require projects to remain profitable if the price of crude falls to USD 35 per barrel. In common with others, they see this as unlikely – their own calculations show rates of USD 70 and up – but set such requirements since they are rationing scarce investment funds.

With oil price expectations at least twice the criterion for sanctioning projects, it can only be called impressive that a debate remains alive in Norway on unprofitable oil projects.

Underinvestment is the problem. Projects with pre-tax profitability well above the socioeconomic required return have not been sanctioned. And those approved are underdimensioned. Operations in the Barents Sea are often compared with activity in other Arctic waters, which are typically characterised by expensive production.

The comparison is inapt because the Barents Sea offers lower costs and quicker start-up. Virtually ice-free, it has little wind. Shallow waters and reservoirs make drilling and development relatively cheap.

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<sup>1</sup> Dn.no, 08.42, 4 August 2018: <https://www.dn.no/nyheter/2018/08/04/0842/Olje/analytiker-spar-ekstrem-lonnsomhet-for-equinor>

<sup>2</sup> <https://www.dn.no/nyheter/2017/04/25/1325/Olje/bare-mosambik-billigere-enn-barentshavet>

<sup>3</sup> Proposition no 80 to the Storting, *Utbygging og drift av Johan Castberg-feltet med status for olje- og gassvirksomheten*



Jonathan Kay, the young Phillips lawyer sent from the company's US head office to Stavanger – the town with “no winter, no summer, no bars”. He is played by British-born actor Bart Edwards.



Vegard Hoel plays legendary Stavanger politician Arne Rettedal with great conviction, while newcomer Anne Regine Ellingsæter has won much praise for her interpretation of Anna Hellevik, his secretary. She took the leap from the rural community of Dirdal to the city of opportunities.

# Seizing the chance to get happy

A TV series about the beginnings of Norway's oil industry has finally been seen in Norwegian homes after winning prizes and praise abroad. And Mette Bølstad, scriptwriter for *Lykkeland* – or *State of Happiness* – has material for several seasons more.

Eldbjørg Vaage Melberg  
Photos: NRK

The production has been largely well-received in the Happy Country as well – even though Stavanger residents of the right age cannot recall that the pietistic chapel culture was so strong then.

They also note that upper-class people depicted in the series fail to speak in the local Stavanger dialect, the way they actually did in the late 1960s.

Its eight parts take the viewer from 1969, when Phillips Petroleum tried to evade its last committed well – which found Ekofisk – to 1972 when trial output from this huge North Sea field was in full swing.

An insight is provided into the way Stavanger politicians, under the leadership of mayor Arne Rettedal, and business leaders such as shipowner Torolf Smedvig, responded at record speed when they saw opportunities to attract a new industry.

The series records how the locally important canning business faced

major problems – and how individuals seized the chance to participate in a fresh adventure.

But this is not a documentary – that has already been made. The story emerges here as a drama which follows developments through characters who engage the viewer.

## Fluent

“I like to delve into other people's reality,” explains Bølstad. “This means I've had to become ‘fluent in oil’. That takes a long time.

“I've got to know enough to be able to carry on a conversation with those who've been involved in the story, and to ask the right questions.”

She has used many sources, including the digital archive at local daily *Stavanger Aftenblad* and Stig S Kvendseth, vice president communications and government relations at ConocoPhillips.

His book *Giant Discovery. A History of Ekofisk Through the First 20 Years* provides a good historical review of the early period.

“I've visited the Norwegian Petroleum Museum, talked with oil historian Kristin Øye Gjerde and read her books,” says Bølstad. “I've also been in contact with contemporary witnesses.

“These include a diver, ‘oil oracle’ Bjørn Vidar Lerøen [former oil journalist and long-serving communications staffer at Statoil] and the NPD.

“Among others are Piers Crocker, head of Stavanger's Canning Museum. I've familiarised myself with the city – and been there a lot.”

This is the town with “no winter, no summer, no bars,” as one of the characters in the series says of Stavanger in the first episode.

“I had to decide where the various players were to work,” Bølstad explains. “Phillips got a lawyer – there wasn't one among the company's first three employees in Stavanger.





Scriptwriter Mette Bølstad with the prize she won for best script at the new Cannes International Series Festival in April 2018. *Lykkeland* also won the prize for best music. Bølstad already has material for several more seasons.

"I decided to use that twist in order to get to grips with the Norwegian regulations and to find a way to involve Arne Rettedal, the legendary local and national politician."

### Visit

A big experience for the scriptwriter was a visit to Ekofisk itself, and she describes flying out to the field as "fantastic. We flew low. It was 07.00. Into the cloud layer – the sun came up – seeing the first platforms was magical. I'd been involved with this for three years, had a strong relationship to it, and now saw the field.

"I was on an old platform – Charlie – where time has stood a little still. I also saw many of the new installations, which are pretty high-tech.

"But it was the mechanical technology which kicked off our economic growth. Those working there were seafarers, men who knew how to run tractors, who knew a lot, had the muscle."

Bølstad observes that operations on the field are so quiet today compared with the reality in 1969-72, when the work was really noisy.

"So it was lovely to come out to the Charlie installation, where some of

the dirty, masculine noisiness still persists," she affirms.

"I haven't wanted to tell a behind-the-scenes story. This is based on fact. We haven't compromised on the historical detail to get the drama to function.

"You use your characters to convey something important. The main thing is to tell a story which allows us to understand ourselves."

"It's also important to have a social perspective – to grasp where our prosperity comes from. Our aim was to present a region moving from poverty to riches."

### Title

"We came up with the title a long time ago," says project manager Tone Rønning at the Norwegian Broadcasting Corporation (NRK), which made the series.

"The original proposal was *Miracle in Stavanger*. Oil is clearly indissolubly linked with our economic good fortune. There's a lot we haven't had to worry about because of it.

"We can naturally show this in documentary format. But a drama allows us to present the past through the people – we get inside their heads

and hearts, which has many advantages."

Since contemporary Norwegians can see the consequences of the petroleum industry, this is not the heart of the story, Rønning explains.

"Its core is about innovation, about seizing the new opportunities. This is about daring to believe that the fairy tale can come true tomorrow."

### Agenda

The NRK spends a lot of money on drama, Rønning points out, so it is important that this output makes its mark. Drama has its justification when it sets the agenda.

She adds that that management expectations at the NRK are crystal clear: "Deliver a world-class product. Our audience doesn't judge Norwegian drama against other home-grown products, but with the best it sees – and that comes from the whole world."

Bølstad would be happy to produce more seasons of *Lykkeland*. But any decision to continue would be up to the NRK, and Rønning says that nothing has yet been fixed.

"We have many good projects and stories waiting to be realised. Tough



Tone Rønning and the NRK have yet to decide whether to commission more seasons of *Lykkeland*.

and brutal priorities have to be set between these."

Viewing figures are not the only consideration which guides what the NRK does, she emphasises. Its social mission must also be taken into account, and then its strategy.

"But it obviously helps that we reach those we want to reach, that they like what they see and that they feel they get value for their licence fee.

"We must have that much respect for the audience. But we can't take decisions on the basis of viewer numbers. Our goal is to bring people

together around shared experiences.

"We want to make them aware of our common history and – which I think is important – stand on history's shoulders when we're going to leap into the future."

Rønning says the NRK hopes that *Lykkeland* provides such a shared experience and an understanding of Norway's history, which is a very important foundation for national prosperity.

"We started work on the series at a time when oil prices were on the way down, just as the fishing industry was in decline back in 1969.

"And we face the same dilemmas today – how far should we continue doing what we're used to, or jump in at the deep end and seize the new chances.

"That's where I find *Lykkeland* a fine inspiration precisely for grasping the opportunities, and not simply sticking with the safe and familiar.

"We must be very grateful for the politicians we had back then. They were concerned with jobs for the whole country – and that oil should benefit the entire nation."



Anne Regine Ellingsæter had to learn both shorthand and typing for her role as Anna Hellevik, Arne Rettedal's secretary. Bølstad's mother dug out her old textbooks from the 1950s and served as a demanding teacher.



Single mother Toril Torstensen, played by Malene Wadel, is a cannery worker with a background in Stavanger's pietistic chapel culture. She thereby represents two of the town's important communities at the time.



Pia Tjelta has said she loved the role as upper-class wife Ingrid Nyman. She is one of Norway's most sought-after actors, and has won great acclaim for her performances on both stage and screen.



**Experience.** Eva Halland has a geology degree from the University of Bergen and joined the NPD in 1984, where she has held a number of specialist and executive posts. She began heading the CO<sub>2</sub> project in 2009.

# Oil hunter now pursuing CO<sub>2</sub>

Geologist Eva Halland used to explore for petroleum. She is now looking for opportunities to capture, transport, store and utilise carbon dioxide.

| Bjørn Vidar Lerøen and Monica Larsen (photos)

**H**alland heads the NPD's project for CO<sub>2</sub> deposition, which is fundamentally about keeping the planet clean so that it remains habitable and provides humans with a good life.

"We must adjust ourselves to becoming pollution-free," she affirms.

Confronted with the claim that global CO<sub>2</sub> levels have been higher in earlier eras, Halland points out that humans did not occupy the planet at these times.

"Today's position is different. To the extent we can do something about CO<sub>2</sub> emissions, it must be done. Recognition of this necessity is growing in many countries.

"The consequences of not doing anything could be serious in both climate and economic terms. Delicate balances could be destroyed."

While the public debate in Norway might give the impression that Norwegians are alone in recognising this, that is not the case.

Halland points to a number of other countries which are increasingly taking these issues seriously, from Arab oil producers to China.

The question is where Norway lies in the race to find good and intelligent solutions. Halland says it is well ahead in terms of thinking and acting because the country started earlier and has more stringent regulations than many other places.

She points to the CO<sub>2</sub> deposition projects on the Sleipner fields in the

North Sea and the Snøhvit development in the Barents Sea.

These demonstrated that the greenhouse gas can be stripped from the wellstream and injected in dedicated formations. Halland adds that the NCS offers a number of storage opportunities.

## Full-scale

Norway is currently pursuing a full-scale carbon capture and storage (CCS) project in the Grenland industrial region south of Oslo, with CO<sub>2</sub> being carried by ship to an intermediate store.

Located at Kollsnes in Øygarden local authority outside Bergen, this facility will then be linked by pipeline to a subsea well on the Johansen formation south of the Troll gas field.

Equinor has sought permission to use this structure as a depository for CO<sub>2</sub>, and that application is now being considered by the Ministry of Petroleum and Energy.

With Shell and Total as partners – see the separate article – this commitment is being made with the aid of public funds voted by the Storting (parliament).

Halland says it is worth noting that efforts to find CCS solutions extend beyond the oil sector, with industry on land showing ever greater interest.

Attention in the Grenland project is concentrated on CO<sub>2</sub> from cement production and from energy generation based on waste incineration.

## Interaction

Halland notes that good solutions will depend on putting projects in a value chain. Future progress needs good interaction between politicians and industry and sharing experience between countries.

She is constantly on the go as an adviser to developing countries and as a participant in collaboration meetings between nations around the North Sea.

A recent trip took her to Australia, where she saw several CCS projects. The most specific was on the Gorgon gas field in Western Australia, operated by US oil company Chevron.

Water is being separated out there for storage in a separate reservoir, while CO<sub>2</sub> gets removed and injected in a yet another formation.

That brings the conversation onto two tracks – storing CO<sub>2</sub> in order to get rid of a troublesome gas, and its use as pressure support for petroleum production.

"It all starts with our ability to store CO<sub>2</sub>," emphasises Halland. "That's the foundation for a value chain."

## Completed

The full-scale project for storing CO<sub>2</sub> near the Troll field in the northern North Sea is due to be completed in 2020-21.

"Once the storage element is in place, we can start thinking about this gas as an instrument for improving recovery," Halland observes.

“But that’ll be a matter of politics and economics. Naturally enough, the challenge will be to create a commercial basis for CO<sub>2</sub> value chains.”

If one question is whether Norway can afford to do this, she says, the counter-question is whether it can afford not to.

Taking a look back, she praises the generation of politicians who established a Norwegian oil and gas regime where gas flaring was banned.

This has been fundamental to Norway’s attitude towards resource management, and Halland places future handling of CO<sub>2</sub> in such a context.

The NPD will be a prime mover in establishing a pilot project for using the greenhouse gas as pressure support in order to improve petroleum recovery.

CO<sub>2</sub> has an interesting potential in

this context on the NCS, and its suitability for the role in both sandstone and carbonate reservoirs has already been documented.

Both Canada and the USA currently have several producing fields with such pressure support, and Halland says Norway has something to build on and learn from.

But the country belongs today in the front rank internationally for CO<sub>2</sub> storage. And few bodies, if any, know more about the NCS than the NPD.

### Overview

“The detailed information we possess about every licence and well in these waters gives us a fantastic overview and knowledge,” Halland points out.

“With our field and well data, we know where the storage opportunities exist. That’s something we can learn

not least from dry wells.

“Our production information will also help us to understand where injection and pressure support could work. Factual field data is essential if we’re going to achieve CO<sub>2</sub> solutions.”

She adds that much of the commitment so far has related to establishing criteria. And the NPD has also produced a CO<sub>2</sub> atlas – initially for the North Sea, and then the whole NCS.

This is a key tool for seeing and understanding the opportunities, Halland says. “If we achieve a good full-scale project, I’ll really start feeling optimistic.”

This is a matter of knowledge, whether the aim is to find oil and gas or to get rid of CO<sub>2</sub> in a way which might also open new commercial opportunities.



**Exploitation.** “Once the storage element is in place, we can start thinking about this gas as an instrument for improving recovery,” says Eva Halland.

## CO<sub>2</sub> breakthrough

The first licensing round for injecting and storing carbon dioxide on the NCS was announced in 2018. This is seen as a breakthrough for good environmental and climate policy, and an important extension of Norway’s offshore licensing system.

When the deadline expired in September, one application had been received from the Northern Light project being pursued by Statoil in cooperation with Shell and Total.

This aims to use the Johansen formation south of the Troll field in the Norwegian North Sea as a depository and storage facility for CO<sub>2</sub>.

The site lies in block 31/5, which was awarded to Statoil, Norsk Hydro and Saga Petroleum as one of three blocks covered by the second licence – PL 085 – for the Troll area.

It supplemented the PL 054 licence awarded as part of Norway’s fourth offshore licensing round with Shell as operator, where huge volumes of gas were identified in Troll during 1979.

The NPD and Gassnova conducted seismic surveying in the 31/5 area during 2008 to map and confirm possible structures which could serve as a CO<sub>2</sub> depository and store.

At that time, the aim was to identify potential sites for storing CO<sub>2</sub> captured from the Kårstø gas processing plant north of Stavanger and/or the Mongstad refinery near Bergen.



**Storage scheme.** A first-ever application for a licence to inject and store CO<sub>2</sub> on the NCS was submitted recently by Equinor together with partners Shell and Total. From left: Diego Alejandro Vazquez Anzola (Shell), Laurence Pinturier (Total) and Per Gunnar Stavland (Equinor) with the NPD’s Eva Halland and Wenche Tjelta Johansen. (Photo: Arne Bjørøen)



# Meet the Geobank

| Bjørn Rasen and Monica Larsen (photo)

Valuable oil samples from virtually every field and discovery on the NCS are stored behind a heavy metal door in the NPD's basement, in temperatures down to -25°C. A few drops at a time for analysis can be provided on request to aid the hunt for petroleum.

The NPD's rock store has quite a reputation. Cores from almost all the wells drilled on the NCS are contained in wooden boxes in something which resembles an Ikea layout.

Geologists from oil companies visit almost daily to study these objects. But the store contains more than cores – so it has now been renamed the Geobank.

A growing number of companies are also requesting drops of oil from the roughly 1 000 flasks holding samples provided by 95 per cent of all Norwegian fields and discoveries.

These must be kept refrigerat-

ed to ensure that the oil survives for as long as possible. Since oxidation can destroy it, oxygen has been replaced with argon in the flasks.

"We supply at least one company a week," says NPD palaeontologist Robert W Williams. "They used to get two millilitres, but we've had to halve that because of increased demand."

He explains that oil comprises a chain of carbon atoms arranged like pearls on a string. These are surrounded by hydrogen atoms and the longer the chain, the thicker the oil. A single carbon atom forms the simplest hydrocarbon – methane.

"The companies use gas chromatography to measure the quantity of each component in an oil sample," Williams explains. "It's like a fingerprint. Such analyses can also say something about reservoir properties and the routes taken by the oil."

**Banked.** Robert W Williams in the refrigerated store which contains more than 1 000 oil samples. Along with the cores and microfossils held by the NPD, these have been redesignated the Geobank.

# Gas strategy weakened

Oil nation Norway needs a gas strategy – at least if the country is to maintain the positions built up in the European market since its first deliveries came ashore in Germany during 1977.

| Bjørn Vidar Lerøen is an author and commentator specialising on oil and gas.

Contrary views exist. Some maintain that Norwegian gas will meet stronger competition and lose ground in an energy market experiencing rapid change.

Supplies from new sources – not least US shale – and growing quantities of renewable energy are eating into market share. Coal is and will remain a competitor in some places. That could make investment in new gas projects uncertain and harder to finance.

Norway's petroleum industry is pursuing a high-profile campaign to emphasise that gas offers major climate benefits by comparison with coal.

The most frequently cited statistic is that Europe's annual carbon emissions would rise by 300 tonnes if coal replaced the gas delivered by Norway.

It might therefore seem paradoxical that the oil companies prefer to hunt for oil, but the arguments there are clear. Crude is easier to handle, primarily in transport terms, and gas has traditionally been regarded as less profitable.

At the 2018 ONS oil conference in Stavanger, Equinor announced a strengthened commitment to the NCS. Plans call for 20-30 exploration wells a year, and an active search for gas.

This strategy has a higher risk pro-

file, which indicates that the biggest player on the NCS will be looking at reservoirs with a lower probability of discoveries.

Executive vice president Arne Sigve Nylund, responsible for Equinor's involvement on the NCS, says that large quantities of gas still lurk beneath the seabed off Norway.

Given the reserves currently proven, the NCS will be unable to offer long-term gas supplies at today's high level for very many more years.

At some point in the 2020s, supply capacity will decline because the old source fields which have contributed to steadily growing Norwegian gas production are in their late-life phase.

This will mean a substantial decline in the gas flow to the Kårstø terminal north of Stavanger in the early 2020s. Unless Norway gives priority to finding more reserves, the following question will become highly relevant: who is responsible for empty – and ultimately rusty – pipelines?

Equinor's renewed strategy for the NCS could mean more than putting gas in the transport system.

Norway's offshore adventure began with oil. That was what it wanted to find. The country talked about oil companies, oil workers, oil policies and the oil economy.

There was nothing wrong with that, because a lot of oil was discov-

ered. So was a great deal of gas, but using "oil" to describe this big new industry created mental images which influenced attitudes and priorities.

Even when the topic is gas, the Norwegian petroleum minister continues to be presented as the "oil minister" at meetings and conferences.

Gas developed in the shadow of oil, even though the NPD noted in its early analyses that resources on the NCS probably split 60-40 in favour of the former.

When Norwegians looked into the future during the early years, they saw that gas would be playing at least as large a role as oil within three decades.

Arve Johnsen, the first CEO of former state oil company Statoil, designated the 21st century as the century of gas on many occasions.

He wanted gas to be priced on a par with oil. An equal quantity of energy should command the same market price regardless of the form it took. This was achieved with Statfjord and Heimdal, but not later.

In some contexts, gas came to be viewed as a waste product accompanying the oil. It has been and continues to be flared in large quantities in a number of oil-producing countries.

Norway made an important value choice at any early stage by prohibiting such flaring. That was one of 10 key policy objectives set in the early



**Supplying Britain.** Norway currently meets about a quarter of the UK's gas consumption, and has reduced the quantity of greenhouse gas released in Britain by more than Norway's own emissions. (Photo: Rune Solheim)

1970s, and has been followed ever since.

The NPD has played and still plays a key role as a driving force for optimum recovery. Troll is a good example, with gas output being curbed to maximise oil production.

However, the opposite approach was taken with Frigg and Snøhvit. In both cases, recovery concentrated exclusively on gas and the oil was lost. It must not be forgotten that the huge gas reserves in Troll were considered marginal when first proven. Large oil resources in thin zones under the Troll gas were also seen as marginal.

What has primarily characterised the development of production from the NCS is that much became more. Recovery turned out to be a lot higher than had been thought possible.

That translated in turn into significantly large sales volumes and revenues for both companies and government. Gas sales have exceeded the most optimistic forecasts.

New production records are set for this commodity year after year, and annual output now exceeds 120 billion cubic metres.

Most of this is transported by pipeline, with some exported in ships from Hammerfest as liquefied natural gas (LNG). The energy quantities involved are enormous.

When an LNG carrier loading at

the Melkøya liquefaction plant reaches 75 per cent capacity, its energy cargo equals annual output from the big Alta hydropower station in northern Norway.

Sales from Snøhvit had to be adapted to big changes in the gas market, given that the field was primarily developed to meet US demand.

The Norwegian gas sellers had contracted to deliver 10.4 billion cubic metres per annum to the Cove Point LNG terminal in Maryland. Then came the shale gas revolution.

With Cove Point converted for exports, the deal to take Snøhvit gas was cancelled. New outlets were found in both Europe and Asia, but competition has become much tougher in recent years.

Gas discoveries are normally seen as riskier than oil finds. The Sleipner fields are a case in point. In 1985, the Sleipner East licensees agreed to sell their gas to the UK.

However, the Thatcher government maintained it had enough gas on its own continental shelf and rejected the deal. This decision came as a shock to Norway.

The British had bought the gas in Frigg and got this piped to St Fergus in Scotland, and Norway took it more or less for granted that they wanted more.

Nevertheless, the Norwegians

landed their biggest victory as gas exporters the following year with the sale of Troll gas to continental buyers – and with the Sleipner volumes thrown in.

British interest in Norwegian gas had not disappeared for ever. Sale of the Ormen Lange gas in the early 2000s proved a new and important breakthrough in the UK market.

Philip Lambert, who heads the internationally recognised Lambert Energy Advisory consultancy, has great faith in Norwegian gas and provides the following example.

Norway currently meets about a quarter of UK gas consumption, and has thereby reduced the amount of greenhouse gas released in Britain by more than Norway's own emissions.

Carbon emissions from the UK are at their lowest since 1894, thanks to the combination of reduced coal consumption, more use of gas and increased renewable energy.

Coal continues to be used, but in much smaller quantities than before. Britain's last coal mine closed just before Christmas 2015. Norwegian gas is defined as part of the UK's energy future.

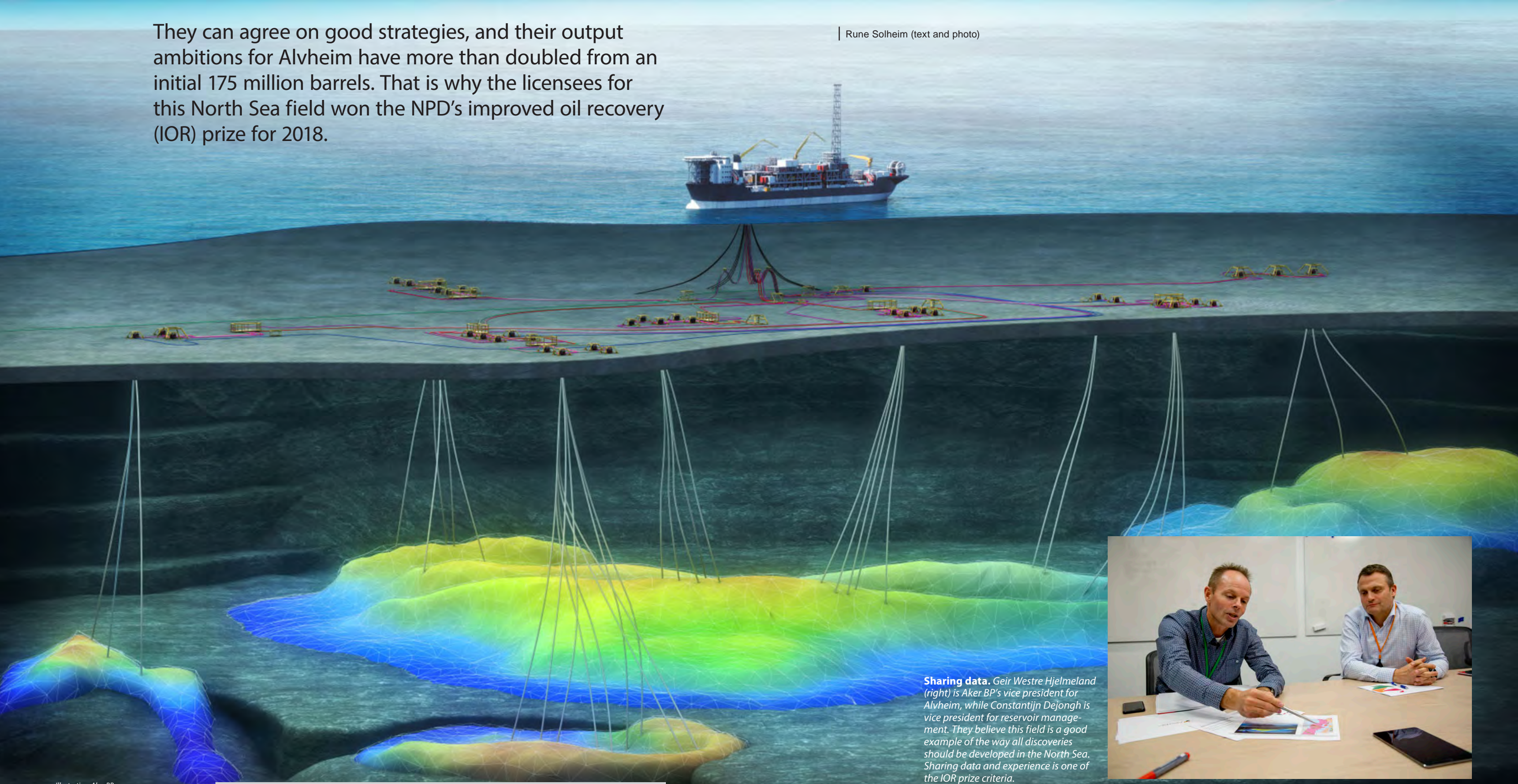
Norway has enough gas pipelines. The challenge for the years to come will be to secure resources to transport through them.

“What has primarily characterised the development of production from the NCS is that much became more.”

# Trio at the top

They can agree on good strategies, and their output ambitions for Alvheim have more than doubled from an initial 175 million barrels. That is why the licensees for this North Sea field won the NPD's improved oil recovery (IOR) prize for 2018.

| Rune Solheim (text and photo)



**Sharing data.** Geir Westre Hjelmeland (right) is Aker BP's vice president for Alvheim, while Constantijn Dejongh is vice president for reservoir management. They believe this field is a good example of the way all discoveries should be developed in the North Sea. Sharing data and experience is one of the IOR prize criteria.



Illustration: Aker BP

The Alvheim field came on stream in 2008. Output is transferred to a floating production, storage and offloading unit.

Aker BP is operator with a 65 per cent interest. ConocoPhillips has 20 per cent and Lundin Norway 15.

Extensive data acquisition has led to the continuous identification, maturation and drilling of new well targets since production began.

Aker BP, ConocoPhillips and Lundin are certainly committed to extracting as much as possible of the oil from the Alvheim reservoir.

That commitment extends right from a very active partnership at production licence level down to the specialist teams who are hands-on with equipment and magnifying glass in the sub-surface.

Work in the licence is characterised by good communication, sharing of data and a solid ability to reach agreement on the commercial deals.

A number of minor licence interests have been combined in a way which means that everyone feels they have got something back for what they contribute to the production collective.

## Stellar

The Alvheim area is a stellar example of the way developments should be pursued in the North Sea, according to Geir Westre Hjelmeland, vice president for Alvheim at Aker BP.

Step one is to discover enough petroleum to support an approved plan for development and operation (PDO). Once production begins, the infrastructure must also be used to locate additional reserves and maximise resource utilisation around the first find.

When Alvheim came on stream in 2008, it produced some 120 000 barrels per day. After almost 10 years in operation, it reached this figure again in 2017. More than half the oil output today comes from discoveries made since production began.

Aker BP is a partner in all the licences covering the area, including satellite fields now tied back to the Alvheim floating production, storage and offloading (FPSO) unit.

Alvheim partner Lundin Norway is also involved in most of the other discoveries, while ConocoPhillips' participation is confined to the parent field.

## Criteria

Adopting new technology has been one of the success criteria for the Alvheim area, both in discovering more oil and in recovering a larger proportion of resources in place.

Constantijn Dejongh is Aker BP's reservoir vice president for the Alvheim area. With a pen hammering on an illustration of the field, he points out that enhancing seismic methods to improve reservoir understanding is very important for IOR.

A third three-dimensional seismic survey was conducted in the Alvheim area last year, allowing the specialists to see where water has intruded and gas expanded in the reservoir.

"We can then see where the oil we still want to get out is located," explains Dejongh. "That helps us to drill an extra well in the right place, for example.

"One of the producers we recently drilled is due to come on stream next week. It's a multilateral with three branches. One is 3 500 metres long, and the overall length exceeds 10 kilometres.

"We're actually vacuuming the reservoir clean of oil in this way. In total, we've drilled more than 100 kilometres of well paths through Alvheim."

Another technique being deployed consists quite simply of drilling many pilot boreholes, which helps to reduce the risk for future wells.

"Where we have good reason to believe oil is present, we stick down a pilot," Dejongh reports. "Taking just a few days, that's an economic way of ensuring sufficient resources exist in the area."

## Injection

Alvheim's reservoir structures are characterised by relatively thin oil columns, where gas injection flows easily down and injected water rises into the oil zone.

Such pressure support is needed

to drive more oil out of the formations, and long horizontal wells represent the best way of developing the field.

The specialists have benefited greatly from using inflow control devices (ICDs) and autonomous versions (AICDs) to choke gas and water from the wellstream before it reaches the FPSO.

"We've just drilled a well on the Gekko field which found an oil column only six-seven metres thick, with large quantities of water below and a lot of gas above," says Dejongh.

"Such formations are challenging to produce, but these are the kind of targets we set ourselves – and we must then adopt the tools and technologies needed to meet them."

Tracer systems are also installed on the seabed well completions, and make use of chemicals which react with oil, gas or water.

When sampling on the FPSO, the specialists can detect what a well is actually producing – which is important for finding out whether the whole well is contributing, adjusting recovery and possibly identifying areas for new drilling.

## Reserves up

Recoverable reserves in Alvheim were put at roughly 175 million barrels of oil equivalent (boe) by the plan for development and production (PDO) presented in 2004.

The amount actually produced from this field is now more than twice that figure, while volumes in the nearby Vilje and Volund discoveries have almost doubled from the original estimates.

With 400 million barrels of oil produced, reserves include 150 million barrels and some 150 million additional barrels have been identified. Further resources are being vigorously sought.

"To recover the proven oil reserves, we must have good uptime on the FPSO and fantastic understand-

ing of the sub-surface in order to position the wells correctly," explains Dejongh.

"We also need the best possible projects with costs as low as possible. At the same time, we require exploration success. So a number of things have to work out."

## Proven

The nearby Frosk discovery was proven in February 2018. Before appraisal wells were drilled, it was estimated to contain 30-60 million boe.

Plans call for the Forsklår and

Rumpetroll exploration wells to be drilled in this area from early next year, followed by a producer on Frosk. This will begin test production less than 18 months after the discovery was made.

Hjelmeland reports that all the oil from new discoveries has so far been tied back to the FPSO, and says it is too early to determine whether the basis exists for more installations.

"If the Frosk wells indicate that more is present there than we currently think, it'll influence our choice of concept. We're optimistic."

Success on satellites Frosk, Trell and Trine as well as further discover-

ies in the actual Alvheim licence are important for continued development of the area.

One interesting possibility exists which has still not been investigated, Dejongh reports. "Hydrocarbons could well exist further down in this area – what we call the 'cellar'."

The deeper sub-surface comprises Jurassic sandstones of unknown permeability and porosity. They could contain oil – or gas. Assessing this from the seismic data can be difficult.

"We can't abandon the Alvheim area in 2045 without having probed these deep strata," says Dejongh.

An exploration programme close to Alvheim resulted in the discovery and development of a number of new fields.

Discoveries outside the immediate vicinity, such as Vilje, Volund, Bøyla and Skogul, have also been tied back to Alvheim.



The NPD's 15th IOR Prize was presented by director general Bente Nyland (left) during a ceremony at the ONS oil show in Stavanger this August. Representative from Aker BP (operator with 65 per cent), ConocoPhillips (20 per cent) and Lundin (15 per cent) were called up to receive the prestigious award. (Photo: Arne Bjørøen)

Pilot boreholes, multilateral wells, extensive use of oil and water tracers, four-dimensional seismic surveys, inflow control devices (ICDs) and autonomous ICDs (AICDs) in the wells are among the innovative technologies used to optimise Alvheim recovery.

## Experienced contributor

Support from ConocoPhillips for operator Aker BP and partner Lundin Norway over further development of Alvheim has ranged from technical sub-surface work and well location to negotiations and agreements.

The licensees in this field, where ConocoPhillips has a 20 per cent holding, were rewarded this autumn with the NPD's IOR prize for 2018.

Many stakeholders have become involved around the field as new discoveries are tied back to its floating production, storage and off-loading (FPSO) unit, reports Øyvind Gundersen.



**Common good.** "When we manage to reach good agreements on the field, the whole nation benefits," says Øyvind Gundersen, manager for partner-operated fields at ConocoPhillips.

He is responsible for several of the partner-operated fields where ConocoPhillips has interests, and leads work on following up the company's holding in Alvheim.

"We've helped to come up with a good model based on sound principles for the division of value between the Alvheim licence and third-party fields," Gundersen explains.

"This is a matter of finding balanced solutions which function for all the players, while also ensuring the best possible utilisation of resources in the area. The work has thereby benefited the whole nation."

ConocoPhillips contributes by

transferring experience both from its own operatorships and from other partner-operated fields in its portfolio.

That includes the new inflow control devices (ICDs) and autonomous ICDs which restrict the intrusion of water and gas from the reservoir into the well. Experience from another of the company's partner-operated fields proved very beneficial here.

"We're very pleased to be able to contribute to the good collaboration in the licence," says Gundersen. "That permits quick decisions in such areas as modifying well paths from single to multilateral at very short notice."

In that context, he points to the occasion when the well and reservoir personnel found an unexpected oil zone in addition to the main column in the Kobra well.

The licence partners were then called together and decided within a few days to drill an additional lateral in the well to access the new zone.

Gundersen also cites a case where ConocoPhillips applied lessons learnt from Alvheim to projects in other licences, including one which involved recovering oil from sand injectites.

The company got Aker BP to accompany it to a meeting with Equinor in order to ensure that experience with such formations was transferred. Another good example of data sharing.

## Active partner



**Risk.** "As a company with an exploration image, we're used to taking risks," says Tove Lie, manager for partner-operated fields at Lundin Norway. This has paid off on Alvheim.

An assertive role is being played by Lundin Norway on Alvheim. The company has experienced specialists who have built up their knowledge of the field over a number of years.

One of the winners of the NPD's IOR prize for 2018 alongside Aker BP and ConocoPhillips, Lundin has a 15 per cent stake in Alvheim as well as holdings in most of the surrounding satellite fields.

Alvheim manager Tove Lie and geologist Hans Oddvar Augedal are two of the company's staff who have contributed actively by sharing knowledge with the other licensees.

"We have experience from various parts of the NCS," observes Augedal. "This gets transferred to other licences where, for example, only one of the companies is a partner."

Lie explains that lessons learnt by Lundin on Volund have been applied to Alvheim, and that the company

has shared its sub-surface knowledge even though a different partnership is involved.

Augedal adds that continuity has existed among the specialists working on Alvheim over the years despite the big operator and licensee changes which have occurred in the area.

In an early phase, a unitisation model was proposed which would have given all the Alvheim partners holdings in the surrounding satellite fields. But that has changed a little along the way, since the companies have set different priorities.

Lie and Augedal think it is advantageous for the operator, at least, to hold balanced interests across the area. Fortunately, this is how things have ended up.

ConocoPhillips has pulled out of some projects. It now retains only a holding in the Alvheim floating production, storage and offloading (FPSO)

unit and not, for example, in Volund and Bøyla.

"This means we've had to negotiate a number of demanding commercial deals," says Augedal. "Since part of Alvheim extends onto the UK continental shelf, agreements have also had to be reached with British interests."

Lundin has been keen to explore, and supportive of trying new methods – something operator Aker BP confirms. Lie maintains this is a matter of daring to take risks.

As a company with an exploration image, Lundin is used to doing that. Drilling in the Alvheim area has been more or less continuous.

"Aker BP's drilling team is very good at listening to the sub-surface and reservoir specialists," affirms Lie. "It stretches itself in a positive way."



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ISSN: 1504-1468

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