

# OIL AND GAS FIELDS IN NORWAY

## INDUSTRIAL HERITAGE PLAN



NORSK OLJEMUSEUM

# THE FRIGG AREA

The Frigg area lies in about 100 metres of water 35 kilometres north of Heimdal and 190 kilometres west of Stord. It embraces the Frigg, North-East Frigg, Odin, East Frigg, Lille-Frigg, Odin and Frøy fields.

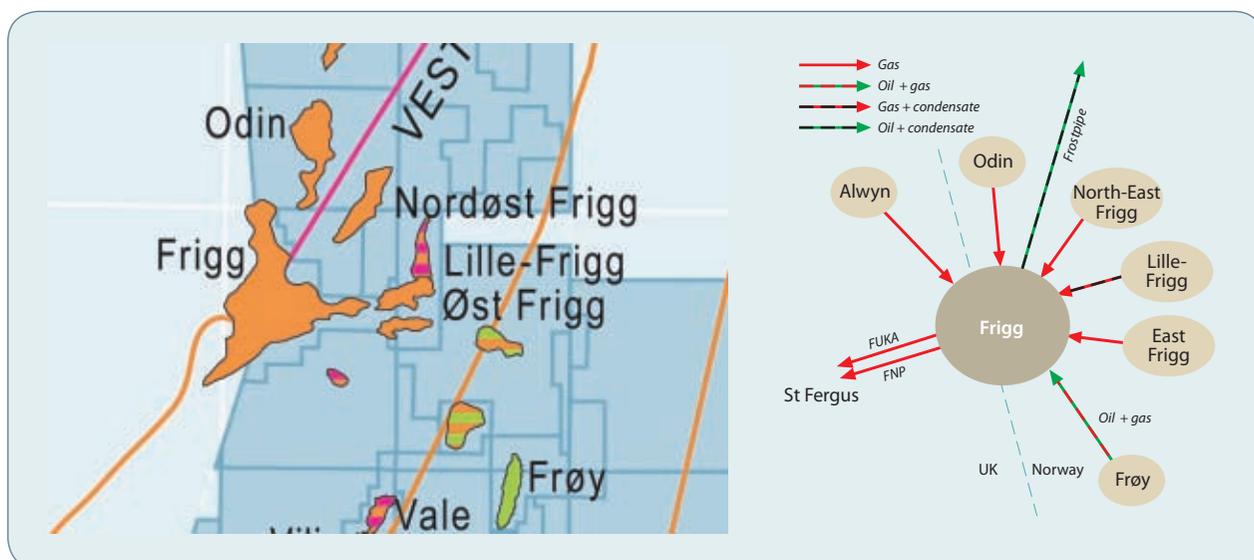
## Frigg

This gas field straddled the UK-Norwegian boundary in the North Sea, and was discovered in 1971 in Norway's block 25/1 and Britain's 10/1 block. Frigg began production on 13 September 1997 and was shut in on 26 October 2004, after producing 116 billion scm of gas.

The TOM group with Total as operator held the UK licence, while Elf Aquitaine Norge was operator for the Petronord consortium on the Norwegian side. A number of factors had to be clarified before a Frigg development could begin. The various licensees first had to agree that the field should be unitised or developed and operated as two independent units. Then the size of Frigg and how much



of it lay on either side of the boundary had to be clarified, and finally a decision had to be taken on landing the gas. Once the licensees had reached agreement, this settlement had to be approved by the British and Norwegian governments. The negotiations over developing Frigg became a touchstone for social exploitation of a petroleum field across national boundaries. A unitisation agreement was



signed by the British and Norwegian authorities on 10 May 1976. This deal marked an important breakthrough in international law. Two countries had reached agreement for the first time on how they would exploit an offshore petroleum deposit with shared installations on both sides of their common boundary.

**Reservoir and recovery strategy**

The Frigg reservoir lies at a depth of 1 900 metres and comprises sandstones with a vaulted shale cap. A thin oil zone underlies the gas. A dark shale deposited in the early Jurassic about 160 million years ago provides the source rock. Frigg’s reservoir properties were very good. The sandstone is clean, with 25-32 per cent porosity and 0.9 to 3D permeability. Frigg was produced through natural pressure reduction.

**Transport**

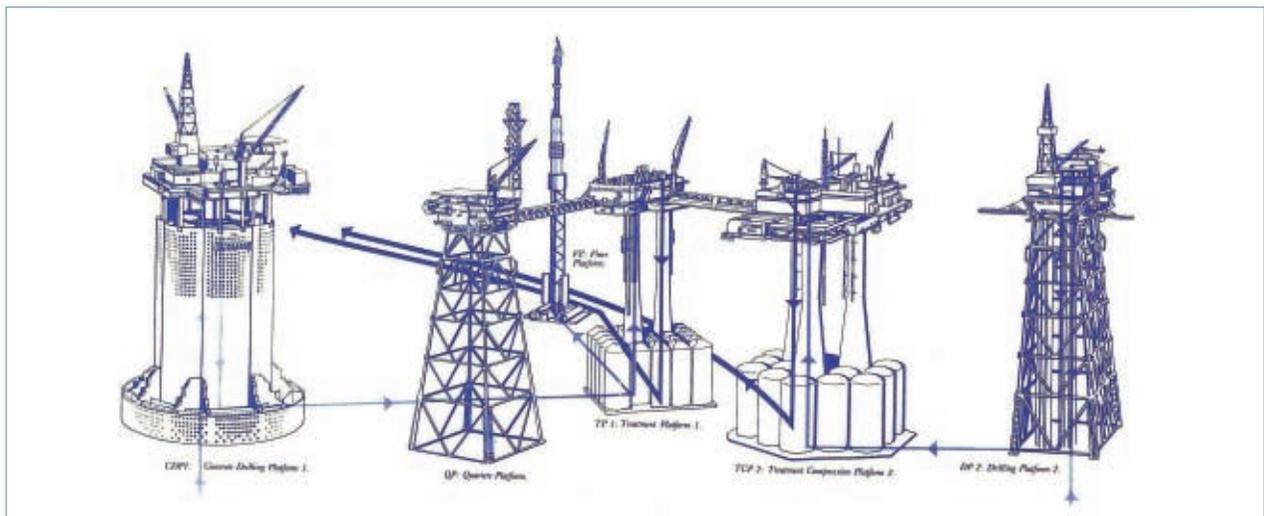
Two parallel transport systems were installed for the field. Construction of the Frigg Norwegian Pipeline (FNP) began in 1974 and was completed in the autumn of 1977, with gas transport starting in the following August. The Frigg UK pipeline (FUKA) was completed in the summer of 1976. Both pipelines to Scotland were operated by Total Oil Marine UK.

Until their abandonment in 2004, the installations on Frigg served as a centre for processing natural gas from the neighbouring Odin, North-East Frigg, Lille-Frigg and East Frigg fields as well as oil from Frøy. Gas from Britain’s Alwyn field was also sent to the field for onward transport to St Fergus through the FUKA. Oil and condensate from Frøy and Lille-Frigg were piped from Frigg to Oseberg through the

<b>Frigg</b>	
Blocks	25/1 and 10/1 (UK)
Production licence	024
Awarded	1969
Total recoverable reserves	116.2 bn scm gas 0.5 mill scm condensate
Discovery year	1971
Approved for development	13 Jun 1974
On stream	13 Sep 1977
Ceased production	26 Oct 2004
Operator	Total E&P Norge
Operations organisation	Stavanger
Main supply base	Dusavik
<b>Licensees</b>	
Norwegian side	
Total E&P Norge	47.13%
Norsk Hydro	32.87%
Statoil	20.00%
<b>UK side</b>	
Total E&P UK	100%

Frostpipe line, for onward transport in the Oseberg Transport System (OTS) to the Sture terminal near Bergen.

Production ceased from Odin in 1994, from North-East Frigg in 1993, from Lille-Frigg in 1999 and from Frøy in 2001. The FUKA currently carries gas from Alwyn to St Fergus. Since 2001, the FNP has been part of the Vesterled transport system which carries gas from Heimdal to Scotland. Vesterled is tied into the old FNP some way downstream from Frigg.



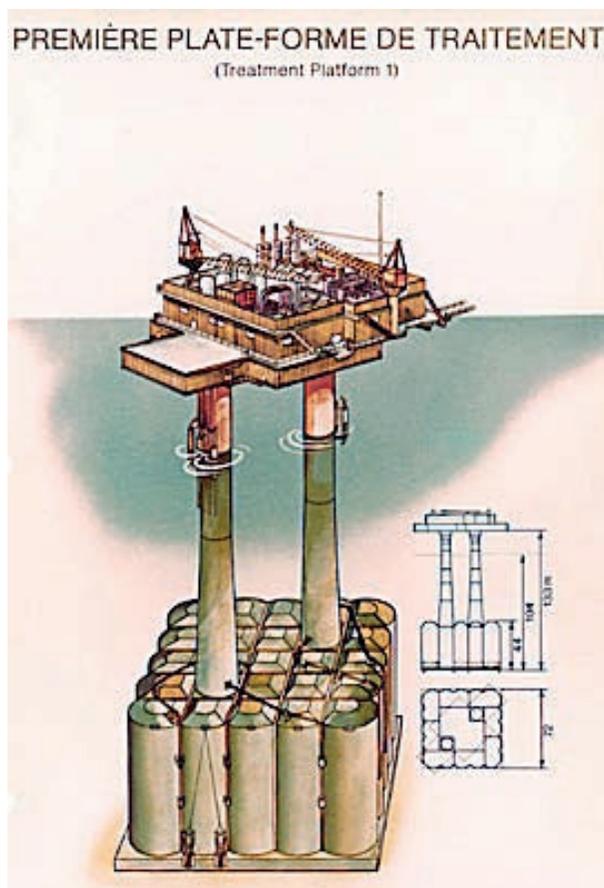
### Development solution

The Frigg installations include three different types of concrete gravity base structure (GBS). TCP2 on the Norwegian side is one of 14 Condeep GBSs in the North Sea, while CDP1 in the UK sector ranks among the four French-designed Doris structures. And TP1, again on the British side, is one of three Sea Tank platforms also designed in France. Installed in 1972, TCP2 and Statfjord A were the first Condeeps on the NCS. The experience gained from building and positioning TCP2 made an important contribution to the development of this type of structure. Frigg's QP and DP2 platforms rest on steel jackets.

### TP1 treatment platform

Frigg TP1 – Treatment Platform no 1 – was one of two gas processing platforms on the field. It stood on the UK side of the boundary and processed gas from the CDP1 drilling and wellhead platform before exporting it through the FUKA to St Fergus.

This installation represented the first concrete GBS built in Britain, at Ardyne Point on Loch Striven west of Glasgow in Scotland, to a design from Sea Tank Company in Paris. The construction con-



TP1. Illustration: Elf



TP1 during construction in Scotland, from the Frigg Field Treatment Platform TP1 brochure. Photo: Elf

tract was awarded in January 1974 to a consortium comprising Sir Robert McAlpine and Sons, which owned the dry dock, and Sea Tank Company. Work started in April that year, and TP1 was installed on Frigg in 104 metres of water on 5 June 1976. Once the GBS was in place, the processing modules were loaded on. TP1 was connected to QP and TCP2 by bridges.

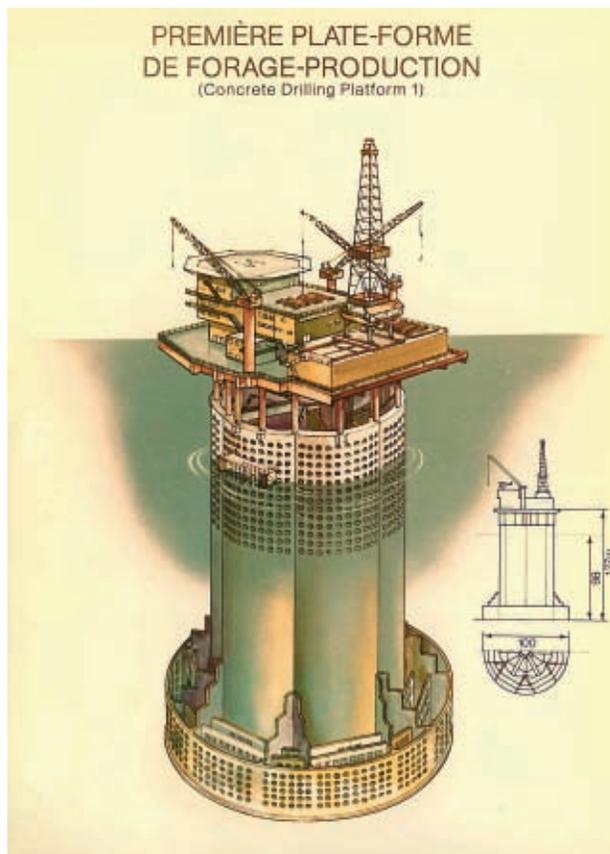
The platform was converted to a riser installation in 1990 and the gas processing plant decommissioned.

### CDP1 drilling and wellhead platform

Concrete Drilling Platform no 1 was a drilling and production installation on the UK side of Frigg.

It was originally designed and built to serve as a compressor platform (MP1) for the pipelines to St Fergus. However, the steel jacket for the DP1 drilling platform was wrecked during its launch on the field. This structure was of the same type as the DP2 jacket. In order to begin gas deliveries on schedule, another solution had to be found. It was accordingly decided to convert the half-completed MP1 to a drilling platform.

The GBS with breakwater and the module support frame were built in reinforced concrete to a design by Europe Etudes in Paris as consultant to C



CDP1. Photo: Elf



Frigg CDP1. Photo: Elf

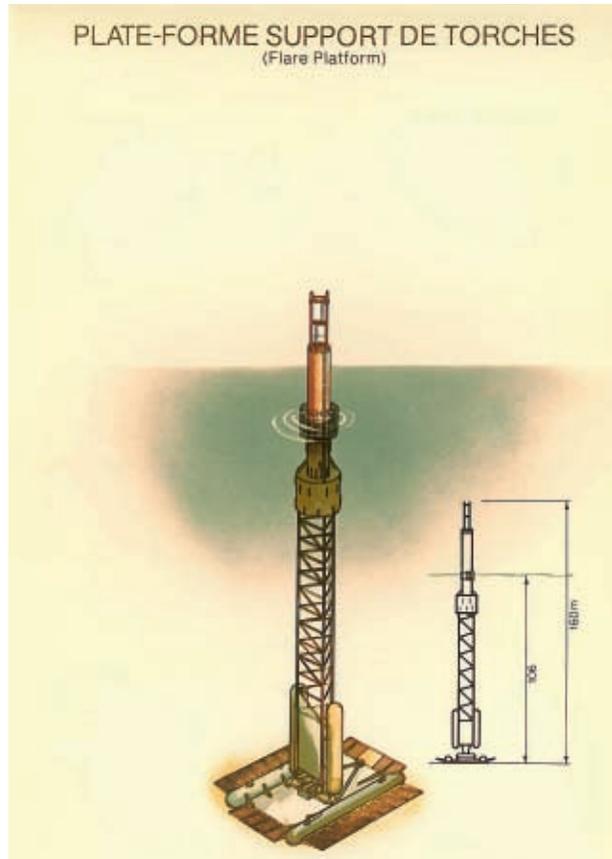
G Doris-Howard. French companies had been early adopters of concrete structures offshore. The first Doris design for the North Sea was the Ekofisk tank in 1973, and the second was CDP1. Construction took place at Åndalsnes in western Norway under the leadership of Norwegian Contractors.

Eighteen modules were placed on the support frame, including wellheads and production equipment, processing systems, and power supply. The quarters module with 80 berths and a helideck was placed at the northern end of the topside, furthest from the drilling derrick. CDP1 was modified in 1984-85 with new modules for drilling operations and quarters, built by Consafe in Sweden.

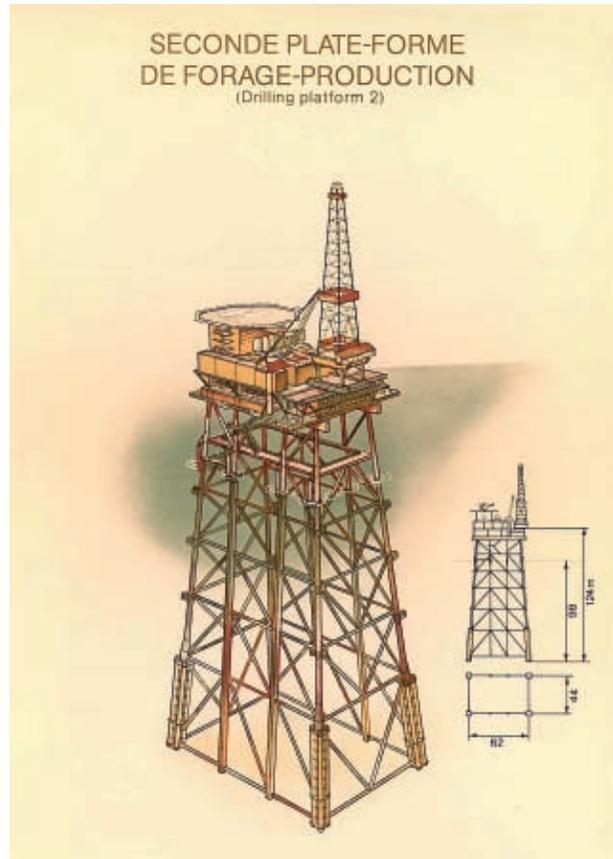
The platform was shut in on 18 November 1990 after 13 years of producing gas for the UK market. After removal of the topside in 2007-08, the GBS alone remains on the field.

### FP flare platform

This compliant column was attached to a foundation on the seabed by a universal joint, which allowed it to move with waves and currents. Tied back to TP1 by a pipeline and umbilical, FP was used to burn off gas during start-up operations and as a safety valve in case an overpressure arose in the Frigg production system. It ceased operation in the



The FP flare platform. Illustration: Elf



DP2. Illustration: Elf

1990s when gas processing ended on TP1, and was eventually removed.

#### DP2 drilling and production platform

This steel installation stood on the Norwegian side of Frigg.

The jacket was installed in 98 metres of water on 11 May 1976.

Drilling of the first wells began in November 1977, and first gas was produced in August 1978 – a year after Britain's CDP1 had come on stream. The special characteristics of the Frigg reservoir, with high permeability, meant that the production wells were concentrated in an area covering just five square kilometres of the field's total 115 square kilometres. Twenty-four wells were drilled with a maximum deviation of 45 degrees. Following a reassessment of the reservoir in 1990, CDP1 on the UK side was shut in and all the wells were drilled from DP2. By then, drilling technology had reached the point where wells could be driven horizontally over long distances.

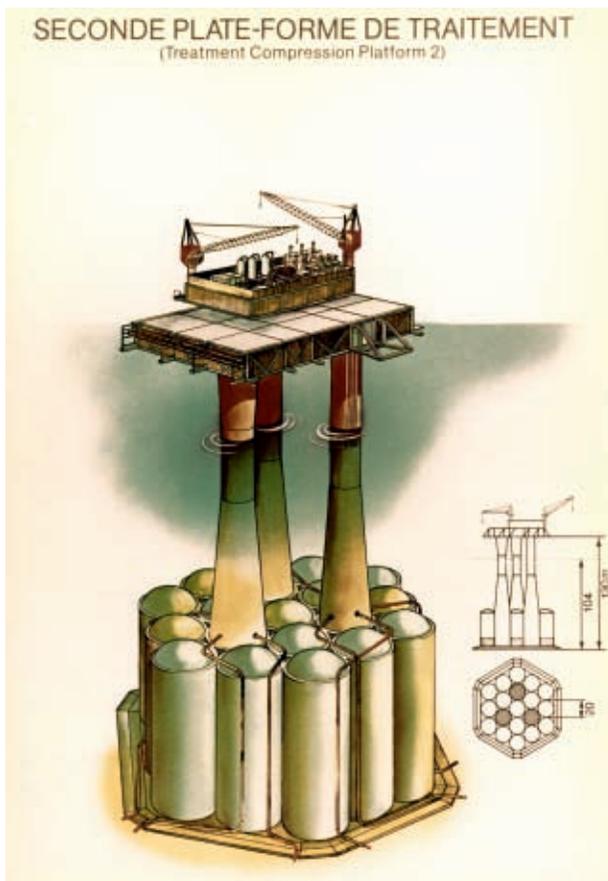
Gas production ceased on 26 October 2004, and DP2 was removed from the field during 2007-08.



The DP2 drilling platform. Photo: Total



Frigg TCP2. Photo: Jan A Tjemsland/Norwegian Petroleum Museum



TCP2. Illustration: Elf

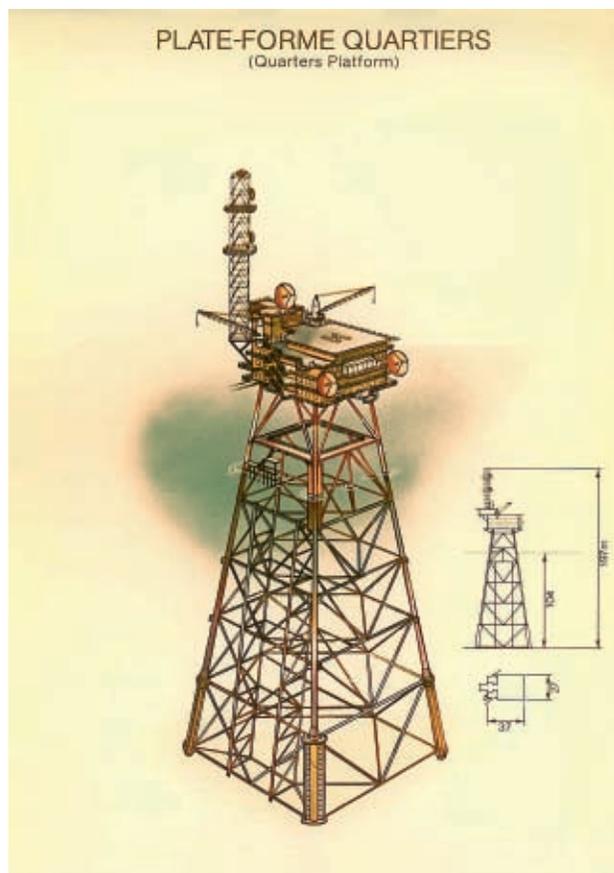
### TCP2 treatment platform

TCP2 – Treatment Compression Platform no 2 – processed gas from the DP2 drilling platform.

Over time, it also received gas from the North-East Frigg, Odin, East Frigg, Lille-Frigg and Frøy satellites. The last of these also delivered oil. TCP2 and Statfjord A were the first Condeeps on the NCS. The GBS comprised 19 concrete cells, each 20 metres in diameter and 42 metres high. Three shafts rose 126 metres above the seabed to support the topside.

Construction of the GBS took place during 1976 in the dry dock at Åndalsnes where the CDP1 structure had been built the year before. TCP2 was installed on the field on 22 June 1977, only a few metres into the Norwegian sector and in 102 metres of water. Processing of gas from DP2 began in August 1978. This output was piped through the FNP via MCP-01 to St Fergus.

Gas ceased to flow through the Frigg system in October 2004, and TCP2 was shut in for good. The topside was removed in 2005-07, and only the GBS remains on the field.



QP. Illustration: Elf

### QP quarters platform

This installation provided accommodation for the three central platforms on the field, and served as the nerve centre for Frigg with control room, helideck and telecommunications equipment. Its four-leg steel jacket was fabricated in France.

QP was installed on Frigg in the summer and autumn of 1975. Plans called for it to be placed entirely on the UK side, but 10 metres in one corner crossed into the Norwegian sector. For practical reasons, the two countries agreed that the border would bisect the bridge between TP1 and TCP2.

Ready for occupation in the summer of 1977, QP



Frigg QP.

Photo: Jan A Tjemsland/Norwegian Petroleum Museum

had a four-storey topside with each deck covering 1 000 square metres. It was topped by the helideck, helicopter hangar, helicopter fuel station, pilot office and the radio and communications shack. The last of these contained systems for communicating with the other platforms as well as Norway and the UK. A tropospheric scatter radio system ensured contact with the MCP-01 pumping platform and St Fergus.

After Frigg ceased production in 2004, QP was used to accommodate those involved in removing the installations. The platform was abandoned during July 2006, and the workforce moved to the Port Reval flotel. QP was removed during 2008.

## North-East Frigg

Elf discovered North-East Frigg in the spring of 1974, 18 kilometres north-east of Frigg. It became the first Frigg satellite to come on stream.

### Reservoir and recovery strategy

North-East Frigg is geologically part of Frigg. It was produced through pressure reduction.

### Transport

Gas was piped to Frigg for processing on TCP2 and transport to St Fergus through the FNP.

### Development solution

The field control station (FCS) was a compliant column which oscillated in 100 metres of water, with six subsea wellheads in a single template tied back to it. The template was installed in June 1981, with divers used both for this job and for subsequent maintenance. Seabed facilities included a manifold system, valve systems and flowlines to Frigg.

Modules for processing, metering and compressing North-East Frigg gas were installed on TCP2 in



North-East Frigg. Photo: Elf

July 1983. To prevent hydrate plugs forming in the gas line from the satellite, methanol was piped from TCP2 and injected into the flowline at North-East Frigg.

The FCS was normally unstaffed, with production remotely controlled from Frigg. North-East Frigg's installations were the first on the NCS to be removed and recycled in 1996.



Illustration: Elf

### North-East Frigg

Blocks	25/1 and 30/10
Production licences	024, 030 and 415
Awarded	1969 and 2007
Total recoverable reserves	11.6 bn scm gas 0.1 mill scm condensate

Discovery year	1974
Approved for development	12 Sep 1980
On stream	1 Dec 1983
Ceased production	8 May 1993
Operator (1974-93)	Elf Petroleum Norge
Operations organisation	Stavanger
Main supply base	Dusavik

### Licensees (1983)

Esso	40%
Elf Petroleum Norge	25%
Norsk Hydro	20%
Total Marine Norsk	12%
Statoil	3%

## East Frigg

This satellite field lies in 110 metres of water about 18 kilometres east of Frigg, in blocks 25/1 and 25/2. Its reserves were estimated at nine billion scm of gas. With the same licensee composition as the Norwegian part of Frigg, East Frigg was the first North Sea field to be produced entirely without surface installations.

### Reservoir and recovery strategy

The reservoir is the same age as Frigg and lies at the same depth. Comprising two separate structures, the field was produced by natural pressure reduction.

### Development solution

East Frigg was developed with two subsea templates

tied to a manifold station. Production was remotely controlled from Frigg, where the gas was also processed before export through the NFP to St Fergus and sale to British Gas under the Frigg contract.

The subsea technology applied was based on the Skuld and SuperSkuld research projects. Development work was pursued in close contact with the oil division of Kongsberg Våpenfabrikk, later Kongsberg Offshore, which was involved both in the project and test phases and at the design and fabrication stage.

Production began in 1988 and ceased in 1997, when the field had produced 9.2 billion scm of gas and 100 000 scm of condensate. The five production wells were plugged during the first half of 1992 and the templates removed in 2001.

### East Frigg

Blocks	25/1 and 25/2
Production licences	024, 026 and 112
Awarded	1969 and 1985
Total recoverable reserves	9.2 bn scm gas 0.1 mill scm condensate
Discovery year	1974
Approved for development	14 Dec 1984
On stream	1 Oct 1988
Ceased production	22 Dec 1997
Operator	Elf Petroleum Norge
Operations organisation	Stavanger
Main supply base	Dusavik
<b>Licensees (1995)</b>	
Elf Petroleum Norge	37.23%
Norsk Hydro	32.11%
Total Norge	20.23%
Statoil	10.43%
(SDFI 1.46%)	

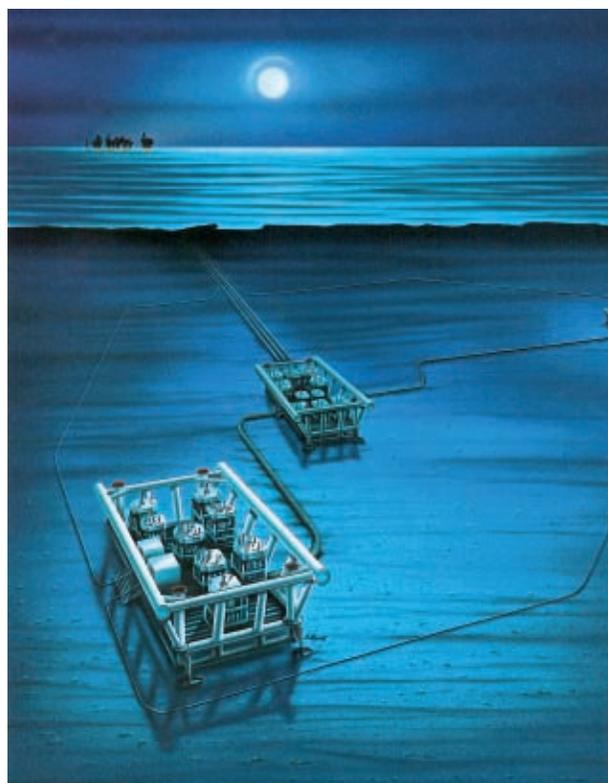


Illustration: Svein Bjur/Elf

## Lille-Frigg

This field was discovered by Elf in 155 metres of water in block 25/2 during 1975. Petronord had received the production licence during 1969 in the second licensing round, when the Frigg licence was also awarded. Cores from the Neptune 7 rig indicated gas at a depth of 3 640 metres with an underlying oil layer. A subsequent well in 1988 determined that the field held gas and condensate under high pressure and temperature (HP/HT). Reserves were estimated at two billion scm of gas and one million scm of condensate.

### Reservoir and recovery strategy

Lille-Frigg is not part of the same geological structure as the Frigg reservoir. It lies at twice the depth, in the Jurassic Brent group. Pressure was 670 bar and the temperature 125°C. The field was produced through natural pressure reduction.

### Transport

Gas was piped to Scotland via Frigg TCP2 and sold to British Gas, with the condensate carried via Frost-pipe and the Oseberg Transport System to the Sture terminal in Norway.



A Lille-Frigg subsea template. Photo: Elf



Illustration: Svein Bjur/Elf

### Development solution

Lille-Frigg was developed as a subsea satellite with three templates, each supporting a single well. One template also contained the manifold for the three wells. Remotely controlled from Frigg, production ceased in March 1999 when 2.2 billion scm of gas and 1.3 million scm of condensate had been produced. The seabed installations were removed in 2001.

#### Lille-Frigg

Block	25/2
Production licence	026
Awarded	1969
Total recoverable reserves	2.4 bn scm gas 1.3 mill scm condensate
Discovery year	1975
Approved for development	September 1991
On stream	May 1994
Ceased production	25 Mar 1999
Operator	Elf Petroleum Norge
Operations organisation	Stavanger
Main supply base	Stavanger

## Frøy

This is an oil and gas field in 120 metres of water about 32 kilometres south-east of Frigg.

### Reservoir and recovery strategy

The reservoir rocks are middle Jurassic sandstones about 3 000 metres deep. Fairly substantial production problems were faced on Frøy because a high water cut created poor lift in the wells. Water was injected in the reservoir to maintain pressure.

### Transport

Oil and gas were carried in two separate pipelines to Frigg TCP2 for processing. The gas was piped to St Fergus, with the oil transported in the Frostpipe line to Oseberg and on to Sture near Bergen. Condensate from Lille-Frigg was carried by Frostpipe to spread investment and operating costs. This transport system became operational on 14 May 1994, when Lille-Frigg came on stream. Frøy started normal production on 15 May 1995.

### Development solution

Frøy was developed with an unstaffed steel wellhead platform remotely controlled from Frigg. Simplified process facilities on this installation separated gas, oil and water.

Two of the field's wells were shut in as early as 1998, and production ceased completely on 5 March 2001 after six years. Frøy had then produced 35 million barrels of oil, 1.7 billion scm of gas and 100 000 scm of condensate.



The Frøy platform. Photo: Total

Det Norske Oljeselskap took over as operator of Frøy in 2006, and a plan for development and operation (PUD) was submitted to the Ministry of Petroleum and Energy in September 2008. The field lies in an area with a number of small oil discoveries which have yet to be developed. Frøy itself is expected to yield 56 million barrels of oil with an initial output of roughly 28 000 barrels per day.

### Frøy

Blocks	25/2 and 25/5	Operator (2006-)	Det Norske Oljeselskap
Production licences	026, 102 B and 364	Operations organisation	Stavanger
Awarded	1969, 1985 and 2006	Main supply base	Dusavik
Total recoverable reserves	35.2 mill bbl oil 1.6 bn scm gas 0.1 mill scm condensate	<b>Licensees (1999)</b>	
Discovery year	1987	Statoil	53.96%. (SDFI 42.00%)
Approved for development	9 Sep 1991	Elf Petroleum Norge	24.76%
On stream	15 May 1995	Total Oil Marine	15.23%
Ceased production	25 Mar 1999	Norsk Hydro	6.05%
Operator (1987-1999)	Elf Petroleum Norge	<b>Licensees (2008)</b>	
		Premier Oil Norge	50.00%
		Det Norske Oljeselskap	50.00%

## Odin

This gas field lies in 103 metres of water 26 kilometres north of Frigg, began production on 1 April 1984 and ceased operation on 1 August 1994. Esso Norge was the operator and sole licensee.

### Reservoir and recovery strategy

Odin's reservoir is geologically part of the Frigg field. It was produced through pressure reduction.

### Transport

The gas was carried in a 20-inch pipeline to Frigg TCP2, where most of the processing took place before it was piped on to St Fergus.

### Development solution

Since Odin was regarded as commercially marginal, the emphasis was on low-cost technical solutions. Esso developed the field with a simple steel platform equipped for limited gas processing as well as a 26-kilometre pipeline to Frigg. The platform was installed in July 1983, with drilling of the 12 production wells starting that December and lasting until January 1985. Although it had its own derrick, the platform relied on the Treasure Hunter rig to handle mud and drillpipe/casing during the drilling phase. Odin began producing on 1 April 1984, as soon as the first well had been completed.

The field ceased production on 1 August 1994 after 10 years, during which 27.3 billion scm of gas and 200 000 scm of condensate were produced and sold to British Gas. In 1996-97, the platform became the first complete production installation to be removed from the NCS. Ninety-eight per cent of it was recycled.



The Odin platform. Photo: ExxonMobil

### Odin

Block	30/10
Production licences	030 and 415
Awarded	1969 and 2007
Total recoverable reserves	27.3 bn scm gas 0.2 mill scm condensate

Discovery year	1974
Approved for development	18 Jul 1980
On stream	1 Apr 1984
Ceased production	1 Aug 1994
Operator	Esso E&P Norway
Operations organisation	Stavanger

### Licensee (1994)

Esso	100%
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